ILLUMINATING ENGINEERING

MARCH 1954

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Featuring—

Utilization Calculations and Measurements

Some Prize-Winning Installations

Lighting Progress Report

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

to you the lighting "missionary"

There's more to lighting than just fixtures and lamps . . . just metal, glass and wire. Selling or specifying better lighting is human welfare work: greater comfort for tired eyes—preservation of eyesight—better working conditions—more pleasant surroundings. It also means: no more torturing eyestrain—less fatigue—less nervous tension—better postures—a healthier disposition.

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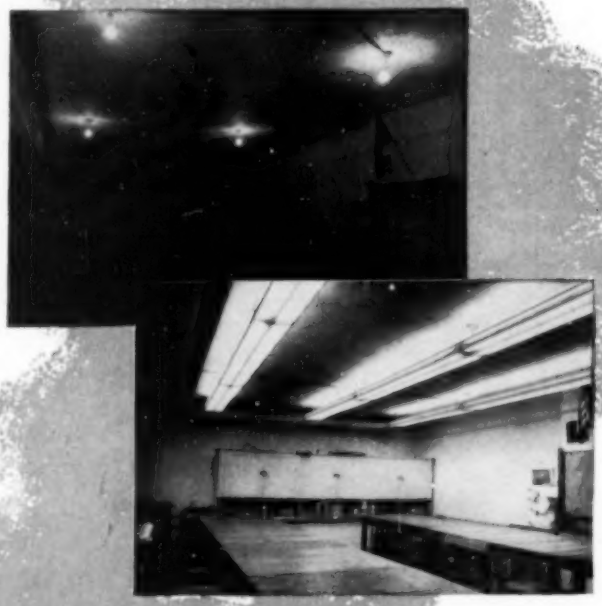

It's not always the glamour—
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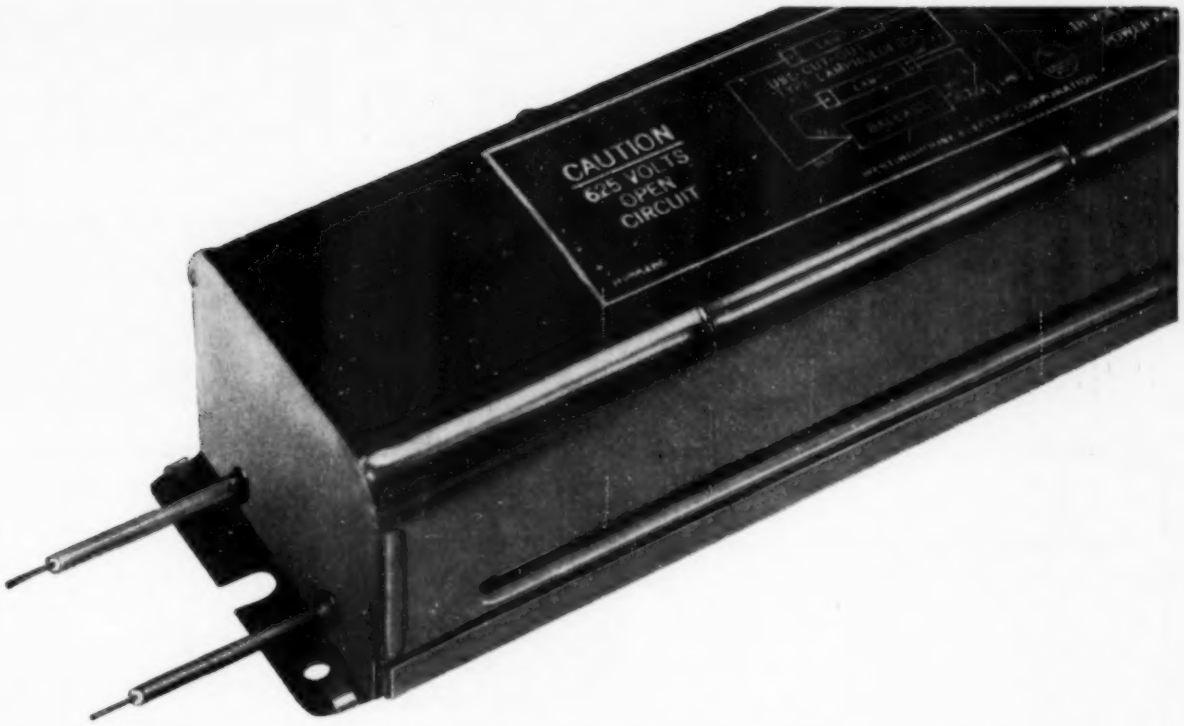


A true, practical advance in lighting economics and efficiencies: the new Westinghouse slimline *lead-lag* ballast

. . . the only ballast of its kind

Once upon a time, ballast manufacturers considered *lead-lag* slimline ballasts as impractical to push because of weight, cost and size. *Westinghouse has changed all that.* New design and engineering have made weight, cost and size *comparable* to series ballasts. These new Westinghouse engineering advances, plus the manifold advantages always inherent in *lead-lag,* make its choice by users of fluorescent lighting a matter of common sense and sound economics. Here's why:

1. Independent lamp operation. You have an accurate check on lamp burnouts—no premature replacement.
2. Maximum lamp life. Tests prove up to 10% longer life than with any other type ballast.
3. Low installation cost because of simple wiring, new light weight and new small size.
4. Stroboscopic effect eliminated. Competent authorities state this effect is greatest with series ballasts . . . that dangerous "stop-go illusion" *can happen* in industrial operations under certain conditions.
5. Wattage loss now only a shade higher than series ballasts . . . to a point where cost is not a factor.

It's economical and practical to insist on new Westinghouse *lead-lag* ballasts in any fixture you buy . . . or to replace old, less efficient ballasts. The Westinghouse *lead-lag* is available for both slimline and preheat fluorescent lamps. Phone your nearest Westinghouse office for full information or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-04346

YOU CAN BE **SURE**...IF IT'S

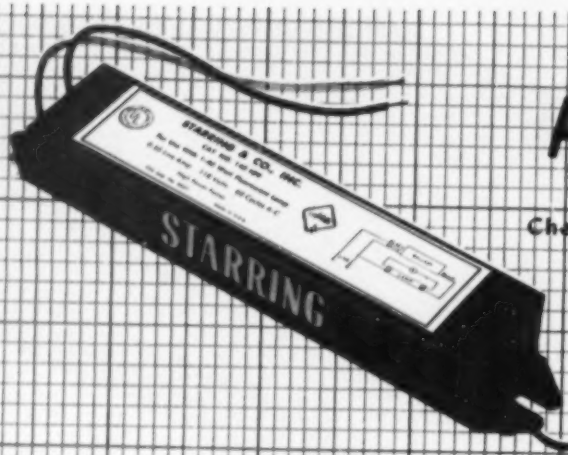
Westinghouse

ANOTHER Fine Ballast!

Check these Electrical Testing Laboratories' Data on the Starring

140HPF

against Supplement 2 to Proposed ASA Specification C82.1



ELECTRICAL TESTING LABORATORIES, INC. PAGE 1 OF 1

TESTS OF FLUORESCENT LAMP BALLASTS

WM. Starring Company Inc. PLANT Bridgeport, Conn. DATE SELECTED 5/28/5 BY E. T. Fagan ETL ORDER NO. 32463-M

CAT. NO. 140 HPF ECP 1 DATE RECEIVED 6/2/5 MFR'S ORDER NO. 3505

RATING: WATTS 146 VOLTS 118 NO. 425 CYCLES 60 DATE TESTED 6/2/5 TESTED BY A.T.C. DATA APPROVED ETC

ETL SPEC. NO.	SIDE	SUPPLY VOLTAGE VOLTS	DIVIDED GOOD CIRCUIT VOLTAGE BY DATA INPUT	BY TYPE INPUT	INPUT TO DIFFERENT LAMPS VOLTAGE VOLTS	LAMP CURRENT AMP	POWER WATTS	PEAK CURRENT AMP	RATIO PEAK TO RMS CURRENT	FREQUENCY AMP	ETL BALLAST LOSS AT RATED VOLTS WATTS	OVERALL POWER FACTOR PER CENT	BASE SHAPE	VOLTAGE ACROSS STARTER TERMINALS VOLTS	ELECTRIC STRENGTH TEST	LINE REG. BAND	FUSE AMP	HEATING TEST AMBIENT TEMP C	0.47 WATT 0.47 VOLT	0.47 WATT 0.47 VOLT				CASE TEMP C
Std	Normal				103.0	0.445	40.0												SPEC MEN NO. 6-6-Normal				
"		213			107.8	0.246	24.0																
"		236			104.0	0.412	39.8																
"		260			102.0	0.476	44.4																
6-6	Blue	118	178	285		0.382	32.0	0.50	1.39	0.598													
	Total	"				0.410	48.0				11.0	99.3											
6-7	Blue	"	176	213		0.386	37.2	0.548	1.44	0.612									Standard Starter				
	Total	"				0.414	48.0				10.8	18.4											
6-8	Blue	106	176			0.346	33.6																
	Blue	118				0.387	37.4	0.550	1.42	0.598					Max Temp.	W			165 F 74.0 C				
	Total	"				0.468	47.0				9.6	97.9			Ambient	W			68 F 20.0 C				
	Blue	130		213			43.8								Ballast	C	90		91.0 F 32.9 C				
6-9	Blue	106	176				29.6																
	Blue	118				0.364	37.6	0.545	1.42	0.608													
	Total	"				0.418	48.0				10.4	77.4											
	Blue	130		213			44.2																
6-10	Blue	106	176				29.2																
	Blue	118				0.382	37.2	0.546	1.42	0.600													
	Total	"				0.416	47.8				10.6	78.3											
	Blue	130		213			43.8																
Std	Normal				103.0	0.445	40.0																
"		213			107.8	0.246	24.0																
"		236			104.0	0.412	39.8																
"		260			102.0	0.476	44.0																

CBM CERTIFIED by ETL

Check them against performance data on any competitive ballast, and you will know why we say "Starring Ballasts are Engineered into Leadership."

140HPF

12" x 2¼" x 1½"
Mounting Length 11¼"
Weight 3.7 pounds

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

MARCH
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No. 3

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1ST FLOOR

2ND FLOOR

New Look

FOR AN OLD BUILDING

...with Lighting by LITECONTROL

This superb remodeling job (in a forty-year-old building) needed custom lighting to show it at its best and provide plenty of balanced light for office work. One versatile fixture — LITECONTROL 4044 — does the job perfectly, lights it just the way everyone wants it.

It's well-illuminated (84 footcandles on the second floor), but even and glare-free. And it's economical on every count.

LITECONTROL 4044 is a louvered fixture that can be used in many ways. Here, it's surface mounted on the first floor, mounted on pendants on the second. It can be hung in rows or individually, as over the door. It goes up easily, is easy to clean and relamp. Louvers swing fully open from either side from spring catches.

LITECONTROL versatility means *custom lighting* with standard fixtures. That means *standard prices.* There are twenty-seven basic fixtures that can be combined or modified to light your job the way you want. For lighting or relighting, call your LITECONTROL representative.

INSTALLATION: Time Credit Office, Union Market National Bank, Watertown, Mass.

ARCHITECT: J. Williams Beal Sons, Boston, Mass.

ENGINEER: Lionel G. Gale, Boston, Mass

DECORATOR: John H. Pray & Sons Co., Boston, Mass.

ELEC CONTRACTOR: Hawes Electric Co., Watertown, Mass.

FIXTURES: No. 4044 4-lamp 40-watt Bipin-louvered, 35°-25° shielding. Surface mounted (1st Floor). On 4" stems (2nd Floor)

CEILING HEIGHT: 11'-0" (1st Floor) — 10'-2" (2nd Floor)

SPACING: 8'-0" on Centers

INTENSITY: 70 Footcandles average in service (1st Floor). 84 Footcandles average in service (2nd Floor)

LITECONTROL *Fixtures*

LITECONTROL CORPORATION

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DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

Before and After.

Bank Sparks Small Town's Relighting Program

First Prize — 1953
Eastern Pennsylvania Section, I.E.S.

EVERYBODY in town is interested in good lighting since the bank was "done over." Portland, Pa. (pop. 1000) has become lighting conscious from the job done there by I.E.S. member R. H. Stewart (Metropolitan Edison Company engineer). Mr. Stewart's installation later won first prize in the 1953 contest for "My Most Interesting Lighting Job" conducted by the Eastern Pennsylvania Section of I.E.S.

With economy in mind, the Bank Board (only bank in town) undertook to be its own general contractor. For its guidance on all details it applied to skilled men in various trades and professions, including fortunately for the result, expert lighting advice. All of these several experts worked together, again to the advantage of the final result.

The old-fashioned beamed ceiling (see "before" picture) was covered with light gray acoustical blocks, lowering the formerly 15-foot ceiling to 12½ feet. This arrangement enabled the lighting engineer to "go modern" with a recessed fluorescent troffer job. In the lobby, three rows of two-lamp troffers are installed in eight-foot sections, on 10-foot centers.

For the important seeing area of the tellers' desks, three rows of three-lamp troffers are used, in eight-foot sections on 10-foot centers. The bookkeeping area uses two rows of three-lamp units in 12-foot sections on eight-foot centers. Offices, coupon booths and directors room use two- and three-lamp troffers strategically placed over the working areas.

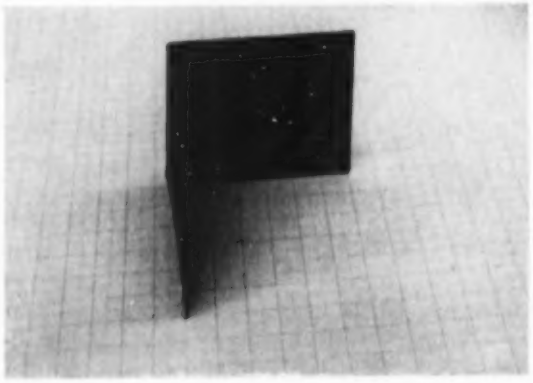
Remodeling of the interior included modern teller stations in light blue, all new light gray steel desks, and a new asphalt-tile floor, all in approved reflectances. Levels obtained, with exceptional visual comfort, are 50 ft-c in all critical areas, and 30 ft-c in general lobby space.

An interesting outcome of this application of good lighting practice, is the awakened interest of the town's merchants in a relighting program of their own.

Directional Lighting Design for a Drafting Room

First Prize — 1953
Southern California Section, I.E.S.

Draftsmen's view, above, shows shielding. Below, matte black shields, six inches square, are set at 90 degrees on drafting table covered with highly specular paper.



Looking the "wrong" way.

FOUR GOALS in the design of the lighting installation in the drafting room at Western Precipitation Corp., Los Angeles, were: a high quality seeing environment; minimum capital investment; minimum maintenance costs; attractive appearance. The installation designed by Oscar Meissner, Illuminating Engineer, City of Los Angeles, to attain these goals won first prize in the Southern California Section's 1953 contest for "My Most Interesting Lighting Job."

The fact that the company planned to occupy the premises during all of the foreseeable future and was willing to live with a fixed arrangement of office equipment determined to a large degree the success of the lighting installation. Enameled sheet metal baffles are arranged in a herring-bone pattern in rows on 5-foot centers. Two-lamp fluorescent channel is installed on the far side of this shielding. The 40-watt T12 lamps are oriented approximately 17 degrees from normal — primarily to reduce triangle shadow and veiling reflection as well as to keep to a minimum the number of lamps exposed to the peripheral vision of the workers. The worst location in the room, from the standpoint of direct glare, is along the side walls, but even here a worker turning a right angle to his normal position toward the opposite side would see relatively few bare lamps.

Illumination levels after 1500 burning hours range from 120 footcandles in the center of the room to approximately 90 in the rear corners — average over the room is 105. The directional nature of the light, falling over the draftsmen's shoulders, is pointed up by readings taken in the center of the room on a 45-degree plane. About 140 footcandles is directed from over the shoulders, about 40 from the front and 80 from the sides. This, of course, varies at different parts of the room.

Architects for the installation were Heitschmidt and Thompson; the consulting electrical engineer, Chauncy Mauk.

Board of Directors Room.

Display Area.

Bottling Plant Remodeled To Modern Utility Offices

First Prize — 1953
Mississippi Chapter, I.E.S.

RECONSTRUCTING industrial areas for entirely different use—offices for instance—is always a challenging problem to the architect and lighting engineer. The drastic transformation in the installation shown here, won first prize for Leigh Watkins III, in the 1953 contest for "My Most Interesting Lighting Job" conducted by the Mississippi Chapter of I.E.S. At the time, Mr. Watkins was a lighting specialist with Mississippi Power & Light, and is now on the lighting staff of Richard E. Cope, Consulting Engineer.

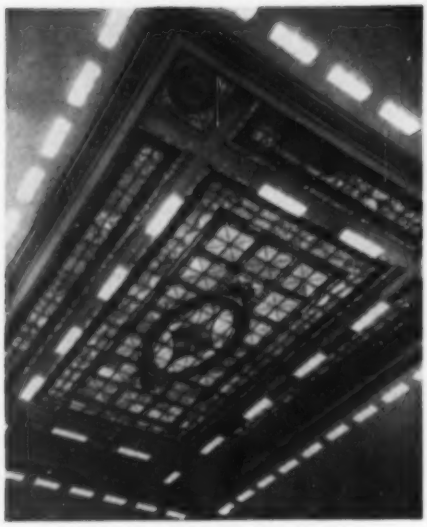
The industrial area remodeled had previously been a bottling plant, with the high ceilings and exposed beams typical of industrial-area construction. From this has been developed, for the Mississippi Valley Gas Company, general office area, sales rooms, general and private offices, and directors room. Sympathetic cooperation between the illuminating engineer and the architects (N. W. Overstreet and Associates) has resulted in *overall* attention to visual requirements, rather than just the installation of proper equipment. Special effort has been made to provide balanced brightness ratios between the recessed luminaires and ceiling, and all other surfaces.

In the general sales area, high reflection floors, furniture, ceiling, and special diffusion of the recessed two-lamp troffers provide 70 footcandles maintained.

Private offices and the directors room all have luminous ceilings, using corrugated acrylic plastic panels of 80 per cent transmission. Wood frames, 2 x 4 feet, with two-foot square opening, designed by the architect, support the panels. Continuous rows of single 40-watt lamp strips are mounted 20 inches above the luminous panels; cavity is painted with 80 RF paint. Maintained illumination in these areas is 40 ft-c.

The sales area is also carefully designed for comfort and high level (70 ft-c) using continuous rows of two-lamp troffers with sagged diffusing glass. For highlighting merchandise, this system is supplemented by recessed incandescent downlights located for best display result.

The pleasing results of the architect-engineer team work on this job have already been beneficial in promoting better lighting in that section of the South.



Solving a Maintenance Problem For a Stained Glass Ceiling

First Prize — 1953
Connecticut Section, I.E.S.

HOW TO LIGHT and maintain a ceiling 42 feet high — and of stained glass at that? Solution of this problem won first prize for Jack Callander, Western Massachusetts Electric Co., Springfield, Mass., in the Connecticut Section's 1953 contest for "My Most Interesting Lighting Job."

The job, admittedly a most challenging one, was the main working area of the Springfield Institution for Savings. Something like 5 to 12 footcandles had previously sifted down on the area, a space 37 feet by 52 feet in size. The ceiling, as mentioned, was 42 feet high and of stained leaded glass.

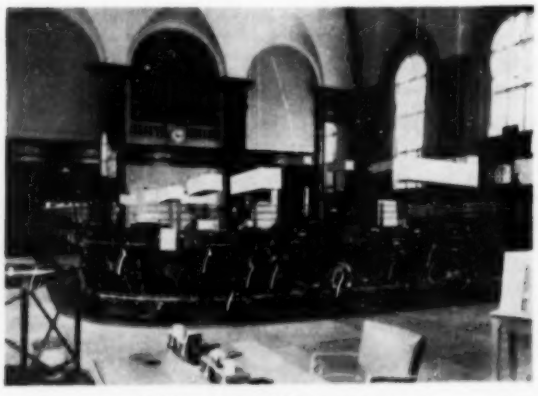
Mr. Callander's recommendations, aimed at 40 footcandles, included the installation of twelve 4-light lens boxes with heat-resisting control lens and reflectors, and two 3-light boxes with the same equipment, all using 300-watt incandescent lamps. These were installed on the under side of the existing false beams. The recessed equipment in the old installation was retained, but the 200-watt lamps were replaced by 100-watt lamps and two-socket extensions, to provide decorative lighting during customer hours.

Illumination was, as planned, 40 footcandles.

The problem of maintenance at least twice a year was a big issue, but the 18-inch I-beams above the ceiling suggested a means of maintenance. A worm gear winch supported and anchored with specially designed brackets completed the top-side equipment for each light box.

Ninety-five feet of steel cable with one end anchored to the beam goes through two metal pulleys, offset on top of the light boxes, and then back up to the winch. Each pulley has a slotted ear to receive a metal key for security while in place. Light boxes are reinforced on the inside with metal strips for rigidity. A ¼ H.P. reversible drill is attached to the winch for a five-minute lowering or raising time.

View of ceiling from above, showing winches.



Luminaires lowered for maintenance.

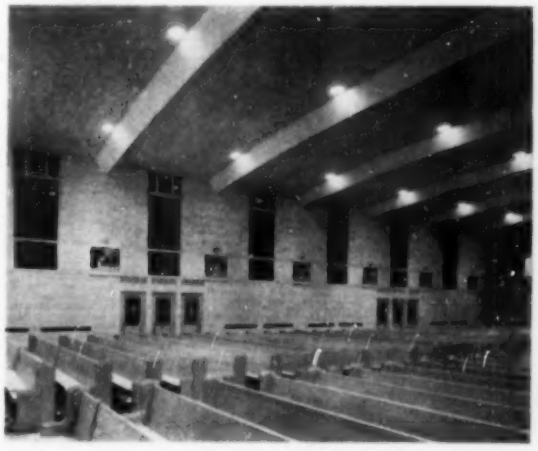
Lighting a Roman Catholic Church Of Contemporary Design

First Prize — 1953
Michigan Section, I.E.S.

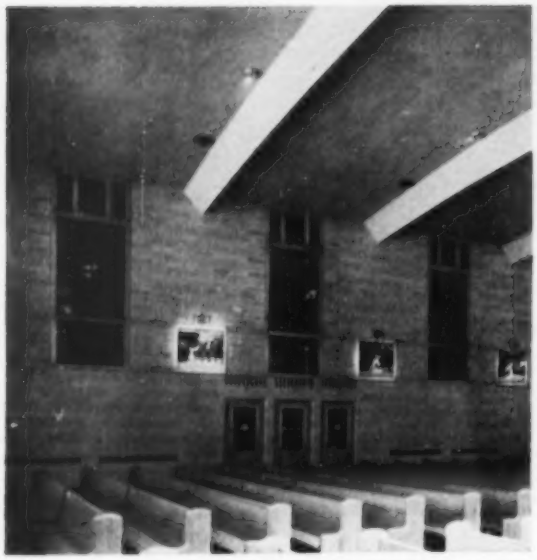
MODERN lighting levels, as well as modern architectural design, was the specific wish of the architect (Arthur Des Rosiers) of Our Lady of Grace Church in Detroit. Traditional church lighting techniques were out of keeping with the design of this building; economy was an additional restriction on the lighting design. The solution called for experienced planning by the illuminating engineer, Alfred C. Sangster, Detroit Edison Company. The final installation took first prize in the 1953 contest for "My Most Interesting Lighting Job" conducted by the Michigan Section of I.E.S.

The church interior is 155 feet by 62 feet with a 22-foot ceiling. Triangular-shaped beams occur in the ceiling, marking it off in 15-foot bays. These beams, 22 inches on each side, provided highly satisfactory shielding for the lighting equipment. Taking advantage of this "built-in shielding," outlets were established on 15-foot centers. For the general illumination, asymmetric mirrored glass reflectors, with louvers, were installed.

Over the balcony and in other areas, asymmetrical reflectors were equipped with concentric ring louvers or roundels. In the nave, all the reflectors were wired for 500 watts and equipped with 300-watt lamps. The balcony reflectors were wired for 300 watts, while 200-watt lamps were installed. In the sanctuary 500-watt lamps were used, to provide a higher level in this area. Special emphasis was placed on the advisability of adequate copper, so that the calculated levels of at least 15 ft-c could be maintained after normal decrease in utilization due to dust and dirt.



Looking toward the rear of the church. Louvers prevent objectionable glare.



Stations of the cross are highlighted by pin-hole spot units, illuminating the stations precisely with no spill-light at all.

Although in Catholic, Lutheran and Episcopal Churches, it is well to try to design the lighting around the altar, in this church the altar was not designed until after completion of the building. In fact, reflectors already installed in front of the sanctuary had to be relocated. Final design of the altar included a Baldichin or canopy in white marble. Since this canopy followed the same design as the ceiling, recessed downlights could be concealed in front of the beams. These units are equipped with 150-watt reflector lamps. Outlets for this feature were established by the marble-setter successfully cutting 5-inch holes in the white marble.

The only fluorescent sources in the installation are beneath the altar table which illuminates its base.

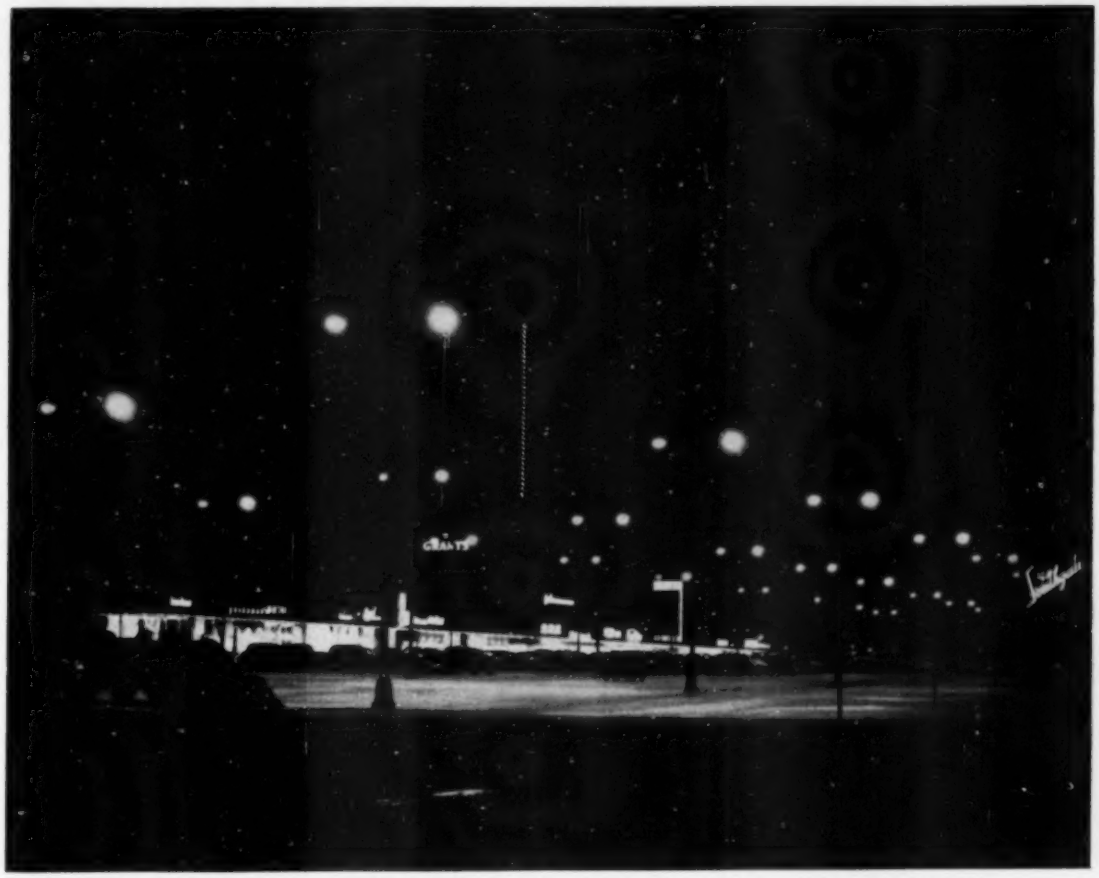
To highlight the stations of the cross, which are exactly square in their dimensions, pin-hole spot units were used, installed in the ceiling between the outside rows of general lighting reflectors. A very unusual effect is obtained with this technique, illuminating the stations precisely with no spill-light at all.

Average illumination for the completed installation was 17 footcandles.

The beauty of this job lies in the fact that as one enters the church, no light source is visible. In a seated position the congregation is still not aware of a light source except by deliberately raising the eyes to the ceiling. Even then, only the rows of reflectors just over head are visible; the louvering prevents objectionable glare in leaving the building.

Publication Box Score for Last Year's M.M.I.L.J. Winners

Last year, a total of 35 installations won first prize in I.E.S. Section and Chapter contests for "My Most Interesting Lighting Job." With the publication, on the preceding pages, of five more of these winning jobs, national attention has been brought to 18 of the 23 which were submitted to ILLUMINATING ENGINEERING for use as application articles. Others will appear in forthcoming issues; and some, as solutions to unusual problems, will be issued as I.E.S. Lighting Data Sheets.



INSTALLATION AT SOUTHGATE SHOPPING CENTER, MILWAUKEE, WISCONSIN.

Lighting a Shopping Center Parking Area

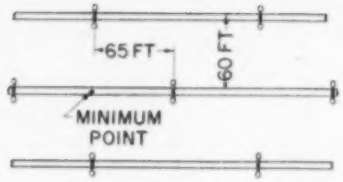
LIGHTING OBJECTIVE: To provide illumination for the attraction, comfort and safety of shoppers arriving in automobiles.

GENERAL INFORMATION: This modern shopping center has a parking area in front of the stores 1250 feet in length by 250 feet in width. There is an additional area in the rear of the stores for delivery and service.

LIGHTING INSTALLATION: Westinghouse Type OV-20 street lighting luminaires having I.E.S. Type III distribution and using the 400-watt 20,000-lumen E-H1 mercury vapor lamps are mounted 33 feet above the pavement on Union Metal tapered steel street lighting standards having twin 4-foot upsweep brackets. The average spacing in the area is 65 feet staggered with a 60-foot width between the three rows of standards. This arrangement gives an average illumination level of 2.5 footcandles with a minimum of 1.8 footcandles between luminaires. An additional row of lighting units is provided at the rear of the stores to illuminate the area for deliveries and service.

(over)

A.I.A. File No. 31



Above: Section of plan view.

Left: Daylight view of parking area.

This high level of illumination not only increases the safety of the customer's person and property by allowing him to easily distinguish objects but also has a high advertising value inasmuch as the level of illumination is three to five times greater than that of the adjacent heavily traveled city streets. The distinctive color of the mercury vapor lighting tends to attract the attention of passing traffic. The modern streamlined equipment presents an attractive up-to-date appearance in the daytime.

Consulting engineers: A. A. Wanty and Associates, Elm Grove, Wisconsin; architects: Grassold and Johnson, Milwaukee; contractor: Andrea Electric Company, Milwaukee.

Lighting data submitted by H. W. Grosh, Westinghouse Electric Corporation, Milwaukee, Wisconsin as an illustration of good lighting practice and to aid in the design of similar installations.

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A Comparison of Measured and Calculated Coefficients of Utilization

By J. R. JONES
JOHN J. NEIDHART

IN 1915[1] and 1920[2] Ward Harrison and E. A. Anderson developed a method for calculating coefficients of utilization for luminaires. This method has been generally referred to as the Three-Curve Method or Harrison-Anderson Method. It was based on measurements of illumination produced by typical arrangements of luminaires that were used at that time. As progress was made in the manufacture of light sources and reflector equipments, luminaire distributions changed and the gradual rise in the standard of living in the United States made higher illumination levels prevalent. Thus, for typical interior areas the number and arrangement of luminaires also changed. Improvements have also been made in illumination meters; the cosine error (which caused measured results to appear low) commonly associated with the older meters has been largely corrected in modern laboratory meters. Thus, there are several reasons why calculated coefficients of utilization that are based on measurements made thirty or more years ago are no longer adequate for the wide variety of luminaires and installation arrangements prevalent today.

This has been recognized for several years and steps have been taken to improve the calculated coefficients. The basic data of Harrison and Anderson were extrapolated to cover a wider variety of luminaire distributions.[3] Also, several efforts have been made to compute mathematically the distribution of light in rooms, the most notable by Moon and Spencer in developing the Interflectance Method.[4] Recognizing the importance of this contribution, the authors developed the zonal factors for determining percentages of flux directed by the luminaire to the walls, ceiling, floor, and work plane and provided charts developed from the interflectance data to facilitate the computation of coefficients of utilization.[5] The zonal factors and charts were developed for, and expressed in terms of, the standard room ratios (room indices) officially adopted by the Illuminating Engineering Society. The technique is sufficiently broad in scope, however, to be readily adapted to any room ratio system the Society seems likely to adopt.

Although this new Zonal or Zonal-Factor Interflectance Method gave every indication of yielding accurate coefficients it remained necessary to prove its merits with actual test data.

Test Facilities

Accordingly, a test room was constructed wherein the average illumination level provided by typical installations of representative luminaires could be measured. The room, which is shown in plan view by Fig. 1, is 18 feet square with two of the walls so arranged that they can be moved (as shown by the dotted lines) for forming a room 9 feet square. The ceiling is divided into four 9-foot square sections, each of which is individually adjustable to any height from 6 feet to 11 feet above the floor. The ceilings were painted flat white with

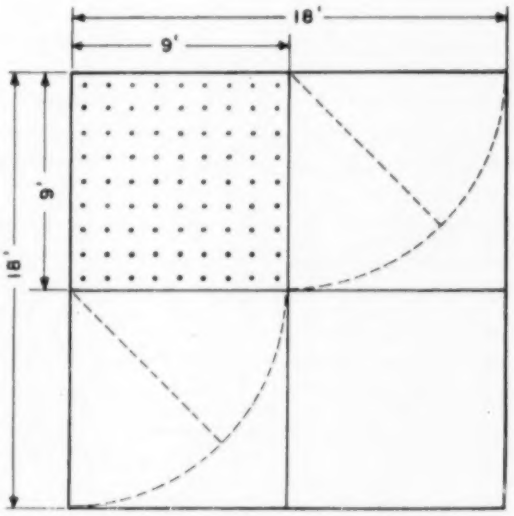

Figure 1. Floor plan of test room illustrating manner in which half of two walls of the eighteen-foot square room swing on pivots to form a room nine feet square. The dots indicate test positions.

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75 per cent reflectance, walls were painted flat gray with 50 per cent reflectance, and the floors were painted a darker gray with 14 per cent reflectance. Test stations at the center of every one-foot square are marked on the floor of the quadrant of the large room which also serves as the entire area of the small room. These 81 stations are indicated by the dots in Fig. 1.

Fig. 2 shows the luminaire locations symmetrically spaced in accordance with good lighting practice and the assumptions upon which both the Harrison-Anderson Three-Curve Method and Zonal Method were based. At each of these locations provision was made for mounting the test luminaires near the ceiling or suspending them any desired distance below the ceiling. All test units were electrically connected to a stable, constant-voltage power supply used exclusively for laboratory test work. During virtually all of the tests, the units in the test room constituted the total load on this power supply. The voltage at the lampholders was checked before and after each set of measurements.

Illumination was measured with a cosine-corrected (see Fig. 3) and color-corrected multi-cell instrument mounted in a self-leveling device and a remotely located (outside the test room) microammeter. Thus, all readings were taken in an empty room — another basic assumption upon which both the Three-Curve Method and the Zonal Method are based. A reading was taken at each of the 81 test points, and the average of these readings is the measured average illumination level. Since everything is perfectly symmetrical, the average of the readings in the one quadrant is equivalent to the average for the entire 18 ft by 18 ft room. This equivalence was verified in every case by using all 81 stations for the 9 ft by 9 ft room data and comparing the data from each of the four quadrants.

Three typical photometric distributions — indirect, general diffuse, and direct — were selected as

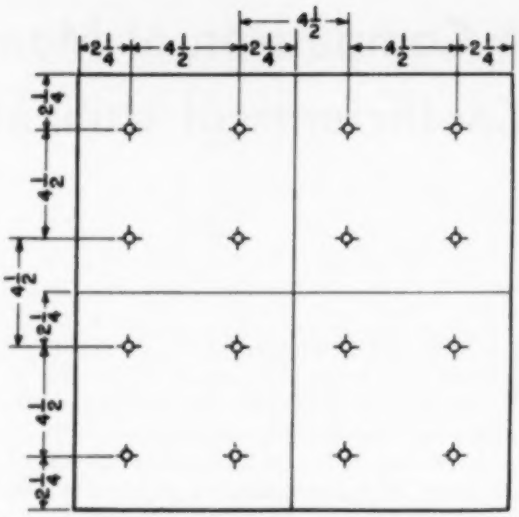

Figure 2. Plan of test room illustrating the locations of the luminaires used in the tests.

being representative of the complete range of luminaire distributions. To keep the scale of the luminaires in the same order of magnitude as the scale of the rooms, it was desirable to limit their size. Thus, a 200-watt silvered bowl lamp mounted in a simple lampholder that would not occlude its light output was used for the indirect "luminaire." The general diffuse distribution was similarly obtained by installing a 200-watt, inside frosted, general service lamp in the same lampholder. The same general service lamps were installed in RLM deep bowl reflectors to obtain the data for direct lighting. All lamps were carefully calibrated before and after each series of tests.

Table I lists all pertinent dimensions for the various room proportions (Room Ratios) for luminaires suspended below the ceiling a distance equal to one-third the ceiling height above the work plane. This suspension length (to light center)

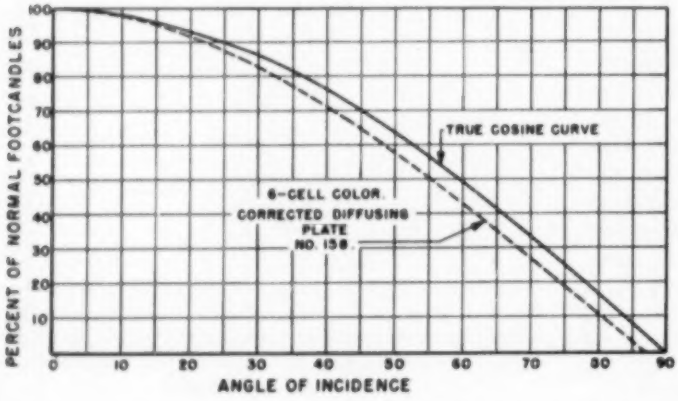

Figure 3. Curves illustrating the degree of cosine-correction of the multicell meter used in measuring the illumination in the test room.

and ceiling height relationship is a basic part of the Room Ratio formulae and is inherent within the Room Index tables. The work plane for all of the test data was located above the floor a distance equal to one-quarter the ceiling height above the floor. This corresponds with the work plane location used in the interflectance data upon which the reflected light components of the Zonal Method are based. The Room Ratios are calculated by the following I.E.S. approved formulae for square rooms.

$$\text{Room Ratio}_{\text{Direct}} = \frac{W}{2MH_{wp}}$$

$$\text{Room Ratio}_{\text{Indirect}} = \frac{3W}{4CH_{wp}}$$

Where

W = room width
MH_{wp} = mounting height above the work plane
CH_{wp} = ceiling height above the work plane

Since a suspension length equal to one-third the ceiling height above the floor is considerably longer than normal luminaire suspension lengths currently employed, test data were also obtained for suspensions equal to one-fifth the ceiling height above the work plane. Complete dimensional information for these shorter suspension lengths is given in Table II. It should be noted that the Room Ratios obtained by the Direct formula are considerably lower with these suspension lengths than they are in Table I with the long suspensions. The Room Ratios obtained by the Indirect formula are, of course, the same regardless of suspension length since ceiling height rather than mounting height is the determining criterion.

The Zonal Method recognizes the difference in illumination that may be expected from luminaires mounted in or near the ceiling and those suspended below the ceiling. To check the accuracy of the data for ceiling mounted luminaires, tests were also made for the general diffuse and direct luminaires mounted as close to the ceiling as was practicable. The light centers of the general diffuse units were 7¾ inches below the ceiling, and the dimensional data are presented in Table III. Table IV shows the corresponding data for the direct luminaires whose light centers were 9½ inches below the ceiling.

Results

All comparison data are shown by means of curves in Figs. 4-8 inclusive and in Table V. In each case the coefficients obtained by illumination measurements in the test room are compared with coefficients calculated by both the Zonal Method and the Three-Curve Method. The calculated coefficients were based upon rooms having reflectances of 75 per cent for the ceiling, 50 per cent for the walls, and 14 per cent for the floors. These reflectances correspond with those of the surfaces in the test room.

The indirect luminaire comparison is shown by Fig. 4 which strikingly demonstrates the greatly improved accuracy of the coefficients calculated by the Zonal Method. It must be remembered that only the lower measured curve represents a fair comparison since the calculated data in both cases are based upon a suspension length equal to one-third the ceiling height above the work plane. A comparison indicates some conservatism in the zonal calculated coefficients with the divergence from the measured curve ranging from about 12

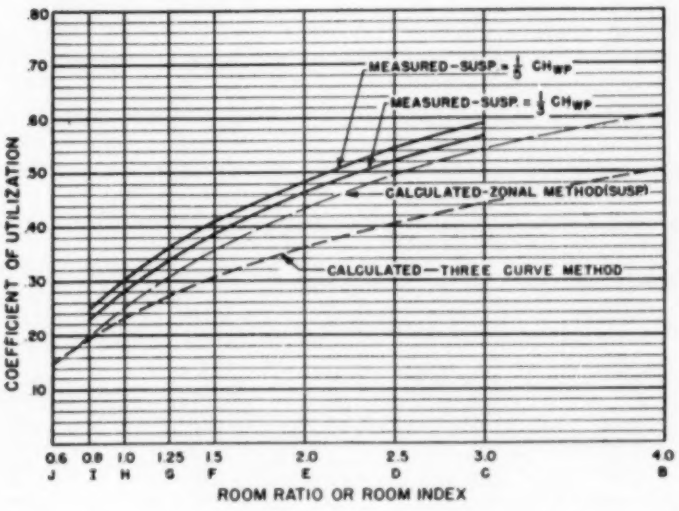

Figure 4. Measured and calculated coefficients of utilization for silvered bowl lamps are plotted against room ratio. The calculated coefficients assume that the luminaire is suspended below the ceiling a distance equal to one-third the distance from the work plane to the ceiling (Susp. = $^1/_3CH_{wp}$), therefore, the calculated curves should be compared only to the curve marked "Susp. = $^1/_3CH_{wp}$." When an indirect luminaire is mounted nearer the ceiling it directs a larger percentage of its flux to the ceiling, which is more effective in producing illumination on the work plane than the walls, so the measured coefficient of utilization is higher, but the room ratio, which is based on the ceiling height above the work plane, remains unchanged.

TABLE I.—Room Dimension Data for Rooms Where the Luminaires Were Suspended One-Third the Distance from the Ceiling to the Work Plane.

Room Width	Ceiling Height Above Floor	Work Plane Height	Ceiling Height Above Work Plane	Susp. Length	Mounting Height Above Work Plane	Room Ratio Direct	Room Ratio Indirect
9′	11.0′	2.75′	8.25′	2.75′	5.50′	0.82	0.82
9′	9.0′	2.25′	6.75′	2.25′	4.50′	1.00	1.00
9′	7.2′	1.80′	5.40′	1.80′	3.60′	1.25	1.25
9′	6.0′	1.50′	4.50′	1.50′	3.00′	1.50	1.50
18′	11.0′	2.75′	8.25′	2.75′	5.50′	1.64	1.64
18′	9.0′	2.25′	6.75′	2.25′	4.50′	2.00	2.00
18′	7.2′	1.80′	5.40′	1.80′	3.60′	2.50	2.50
18′	6.0′	1.50′	4.50′	1.50′	3.00′	3.00	3.00

TABLE II.—Room Dimension Data for Rooms Where the Luminaires Were Suspended One-Fifth the Distance from the Ceiling to the Work Plane.

Room Width	Ceiling Height Above Floor	Work Plane Height	Ceiling Height Above Work Plane	Susp. Length	Mounting Height Above Work Plane	Room Ratio Direct	Room Ratio Indirect
9′	11.0′	2.75′	8.25′	1.65′	6.60′	0.68	0.82
9′	9.0′	2.25′	6.75′	1.35′	5.40′	0.83	1.00
9′	7.2′	1.80′	5.40′	1.08′	4.32′	1.04	1.25
9′	6.0′	1.50′	4.50′	0.90′	3.60′	1.25	1.50
18′	11.0′	2.75′	8.25′	1.65′	6.60′	1.36	1.64
18′	9.0′	2.25′	6.75′	1.35′	5.40′	1.67	2.00
18′	7.2′	1.80′	5.40′	1.08′	4.32′	2.08	2.50
18′	6.0′	1.50′	4.50′	0.90′	3.60′	2.50	3.00

TABLE III.—Room Dimension Data for Rooms Where the Luminaires Were Suspended 0.65 Feet Below the Ceiling.

Room Width	Ceiling Height Above Floor	Work Plane Height	Ceiling Height Above Work Plane	Susp. Length	Mounting Height Above Work Plane	Room Ratio Direct	Room Ratio Indirect
9′	11.0′	2.75′	8.25′	0.65′	7.60′	0.59	—
9′	9.0′	2.25′	6.75′	0.65′	6.10′	0.74	—
9′	7.2′	1.80′	5.40′	0.65′	4.75′	0.95	—
9′	6.0′	1.50′	4.50′	0.65′	3.85′	1.17	—
18′	11.0′	2.75′	8.25′	0.65′	7.60′	1.18	—
18′	9.0′	2.25′	6.75′	0.65′	6.10′	1.48	—
18′	7.2′	1.80′	5.40′	0.65′	4.75′	1.89	—
18′	6.0′	1.50′	4.50′	0.65′	3.85′	2.34	—

TABLE IV.—Room Dimension Data for Rooms Where the Luminaires Were Suspended 0.79 Feet Below the Ceiling.

Room Width	Ceiling Height Above Floor	Work Plane Height	Ceiling Height Above Work Plane	Susp. Length	Mounting Height Above Work Plane	Room Ratio Direct	Room Ratio Indirect
9′	11.0′	2.75′	8.25′	0.79′	7.46′	0.60	—
9′	9.0′	2.25′	6.75′	0.79′	5.96′	0.75	—
9′	7.2′	1.80′	5.40′	0.79′	4.61′	0.97	—
9′	6.0′	1.50′	4.50′	0.79′	3.71′	1.21	—
18′	11.0′	2.75′	8.25′	0.79′	7.46′	1.21	—
18′	9.0′	2.25′	6.75′	0.79′	5.96′	1.51	—
18′	7.2′	1.80′	5.40′	0.79′	4.61′	1.95	—
18′	6.0′	1.50′	4.50′	0.79′	3.71′	2.42	—

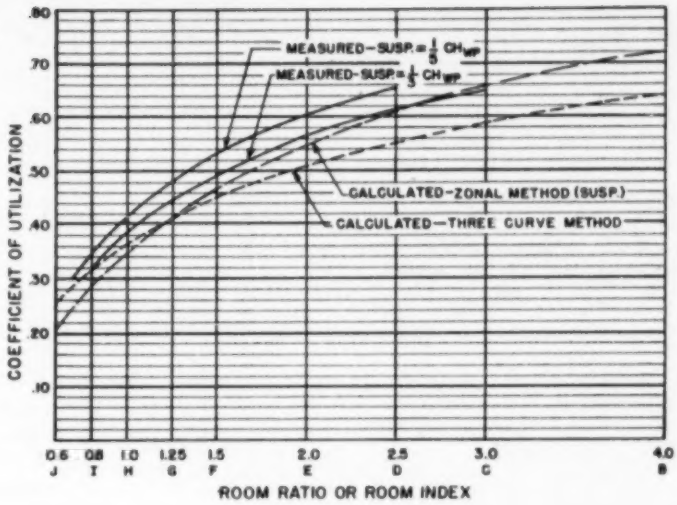

Figure 5. Measured and calculated coefficients of utilization for bare general service lamps are plotted against room ratio. The Zonal Method calculated coefficients should be compared to the measured curve marked "Susp. = $^1/_3CH_{wp}$ since these calculated coefficients are for suspended luminaires which assume the luminaire is suspended below the ceiling a distance equal to one-third the distance from the ceiling to the work plane. The Three-Curve coefficients for general diffuse luminaires do not assume any specified suspension distance so they may be compared to both curves of measured data.

per cent in the .8 (I) and 1.0 (H) rooms to about 4 per cent in the 3.0 (C) and 2.5 (D) rooms. The Three-Curve coefficients for these silvered bowl lamps, on the other hand, range from 22 per cent low for a room ratio of 0.8 to 30 per cent low for a 3.0 room ratio. The soundness of the Zonal Method is further indicated by the parallel relationship between the curves for the Zonal calculated and the measured data. The fact that the Zonal coefficients are slightly lower than the measured values is probably because the ceiling interflectance values are considered by the authors of the Interflectance Method to be slightly conservative for high narrow rooms.

The current practice of hanging luminaires somewhat closer to the ceiling than is imposed on both calculation methods by the present room ratio system, results in higher utilization as shown by the upper curve in Fig. 4. This increases the divergence between calculated (by either method) and measured data an additional 5 to 8 per cent, but the only practical method of recognizing the shorter suspension length is to change the room ratio and room index system. It is significant to note that the Zonal Method can be readily adapted to any change in the room ratio formula that may be developed in the future.

Fig. 5 shows the comparison of coefficients for general-diffuse luminaires. Here the maximum divergence between the zonal calculated and measured coefficients is less than 9 per cent when the luminaire suspension length is one-third the ceiling height above the work plane as is assumed in the Zonal Method calculations for suspended luminaires. The Three-Curve calculated coefficients for general diffuse luminaires do not assume any speci-

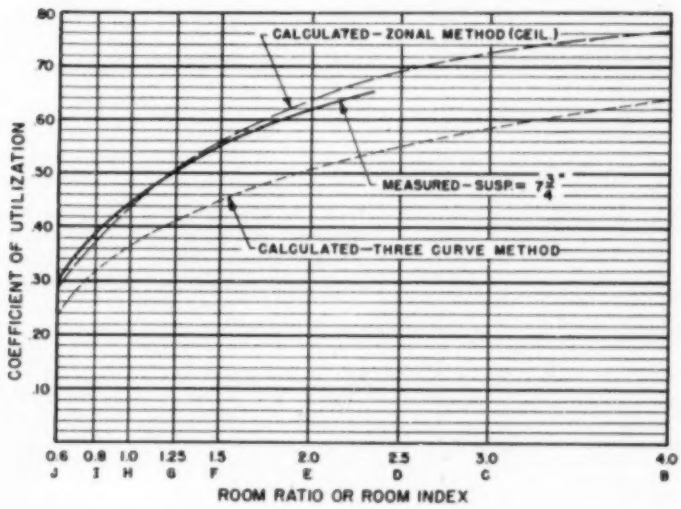

Figure 6. Measured and calculated coefficients of utilization for bare general service lamps are plotted against room ratio. The lamps were ceiling mounted when the test measurements were made.

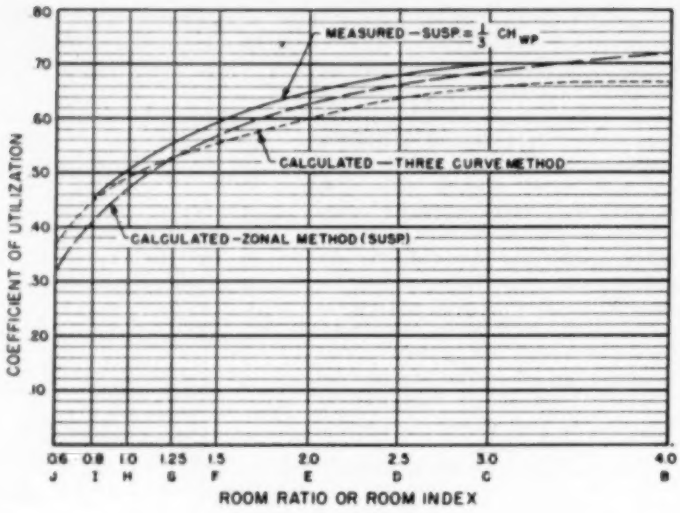

Figure 7. Measured and calculated coefficients of utilization for general service lamps in suspended RLM deep bowl reflectors are plotted against room ratio.

fied suspension length, so they must be compared to both of the curves representing the measured data, thus reducing somewhat the apparent accuracy that might be assumed by comparing them with only the curve marked "Susp. = $\frac{1}{3}CH_{wp}$" as should be done in the case of the zonal coefficients.

Although the effect of shorter suspension lengths is somewhat greater in Fig. 5 than it was in Fig. 4, the difference is due entirely to the change in room ratio resulting when a higher mounting height above the work plane is used in the direct formula. The measured average illumination level was changed only slightly (approximately 2 per cent) by shortening the suspension from one-third the ceiling height above the work plane to one-fifth the ceiling height above the work plane.

When the inside-frosted, general service lamps were ceiling mounted (light center 7¾ inches below the ceiling) the measured curve shown in Fig. 6 was obtained. The measured data compares very favorably with the coefficients calculated by the Zonal Method for ceiling mounting. This tends to prove that if the room ratio is to be calculated by the formula for direct luminaires, the calculation technique must recognize whether the luminaire is ceiling mounted or suspended (as is done in the Zonal Method). The Three-Curve Method uses the formula for direct luminaires but includes no provision for differentiating between suspended and ceiling mounted luminaires, and this results in a very considerable error as shown by the displacement between the measured and Three-Curve Method curves.

The results of the final series of tests with RLM deep bowl luminaires representing direct distributions are shown by Figs. 7 and 8. Fig. 7 includes

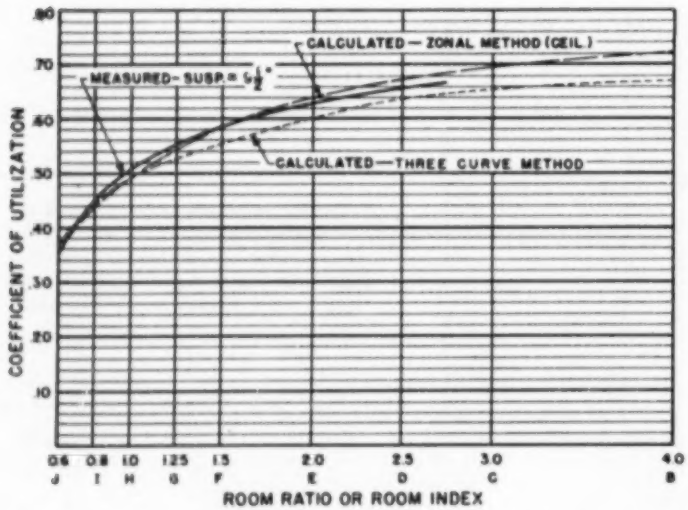

Figure 8. Measured and calculated coefficients of utilization for ceiling mounted general service lamps in RLM deep bowl reflectors are plotted against room ratio.

TABLE V.—Measured Coefficients of Utilization.[1]

Figure 4				Figure 5				Figure 6		Figure 7		Figure 8	
Susp. $= {}^1/_3 CH_{wp}$		Susp. $= {}^1/_3 CH_{wp}$		Susp. $= {}^1/_3 CH_{wp}$		Susp. $= {}^1/_3 CH_{wp}$		Susp. = .65 ft.		Susp. $= {}^1/_3 CH_{wp}$		Susp. = .79 ft.	
Room Ratio	C. U.	Room Ratio	C. U.	Room Ratio	C. U.	Room Ratio	C. U.	Room Ratio	C. U.	Room Ratio	C. U.	Room Ratio	C. U.
.82	.245	.82	.228	.68	.298	.82	.318	.59	.302	.82	.452	.60	.35
1.00	.302	1.00	.280	.83	.365	1.00	.384	.74	.362	1.00	.520	.75	.425
1.25	.370	1.25	.340	1.04	.428	1.25	.450	.95	.429	1.25	.576	.97	.502
1.50	.418	1.50	.366	.125	.483	1.50	.490	1.17	.473	1.50	.615	1.21	.564
1.64	.434	1.64	.432	1.36	.509	1.64	.506	1.18	.506	1.64	.598	1.21	.525
2.00	.499	2.00	.456	1.67	.566	2.00	.568	1.48	.549	2.00	.643	1.51	.588
2.50	.558	2.50	.523	2.08	.614	2.50	.616	1.89	.615	2.50	.685	1.95	.624
3.00	.580	3.00	.559	2.50	.658	3.00	.652	2.34	.642	3.00	.683	2.42	.655

[1]The dimensions of the rooms in which the above coefficients were measured are listed in Tables I to IV. The dimensions of the rooms where the suspension length is $^1/_3$ the ceiling height above the work plane (Susp. $= {}^1/_3 CH_{wp}$) are listed in Table I, those in which the suspension length is $^1/_3$ the ceiling height above the work plane in Table II, those in which the suspension length is .65 feet in Table III and those in which the suspension length is .79 feet are listed in Table IV.

the curves for the suspended condition, and the 2 to 12 per cent difference between the calculated and measured data indicates that the Zonal Method is reasonably accurate. Even greater accuracy in the Zonal Method calculations are shown in Fig. 8 which includes the data for near-ceiling-mounting of the luminaires (light center 9½ inches below the ceiling).

Conclusion

The illumination in any interior area consists of flux radiated directly to the work plane by the luminaires (Direct Ratio) plus flux reflected to the work plane by the room surfaces. The Direct Ratios obtained by Zonal Method calculations can be checked by precise point-by-point calculations. Such checks have been made and good agreement obtained. Thus, it has not been necessary to take measurements in rooms having low reflecting surfaces. The tests reported herein have, therefore, been limited to cases in which a significant part of the illumination is produced by flux reflected to the work plane. Since the divergences between the measured and calculated coefficients are not great, the tests are indicative of the improved accuracy that can be obtained from the Zonal-Factor Interflectance Method of computing coefficients of utilization.

Acknowledgments

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DISCUSSION

W. M. POTTER*: The authors have continued their studies of the zonal approach to utilization values with tests in certain rooms with a single pattern of reflectances and one spacing of luminaires. All such measurements contribute welcome knowledge, but need careful analysis to determine their full significance.

With wide distributions and relatively high reflectance values a high degree of cosine correction for the test cell is important. That shown in Fig. 3 is, of course, typical of the multi-cell instruments. I am informed that the cosine correction of such instruments is somewhat better than that obtained with the etched opal glass test plate used with the better visual instruments. We have used a turret-type test cell much a much closer correction. This was described by A. H. Taylor in ILLUMINATING ENGINEERING, in 1951.[1]

The authors emphasized earlier the importance of specific relationships between spacing, suspension distance and mounting height and have published detailed tables. However, for their tests, they chose a constant spacing of 4½ feet for all rooms, with the result that the ratios vary considerably — in fact, some are beyond the range of their tables. Have they since established that the variable of number of units was not as significant as estimated, at least in some rooms? Or, have new factors for the specific test conditions been calculated where needed and employed in their comparisons? Their spacing-to-mounting-height ratio is as high as 1.5; spacing-to-suspension ratio ranges from 1.6 to 5.7, whereas their published tables were based on a value of 0.8 or less. Without specific data, one cannot evaluate the effects, if any, of these different conditions.

It is noted, however, that in the cases of constant suspension length (Table V, Figs. 6 and 8, Bare Lamp and Deep Bowl types respectively), an abrupt discontinuity in the room-ratio utilization curve occurs when the change is made from a 9-foot to an 18-foot room. The constant suspension distance means a varying ratio of suspension to ceiling-height above the work-plane, changing abruptly at this point. The range for Fig. 8 is from 0.096 to 0.176 for each room size.

Another basis used in their tests is of interest. In their

*General Electric Co., Nela Park, Cleveland, Ohio.

1952 paper, the authors considered that direct fixtures were mounted above the floor a distance four times the work-plane height, whether they were suspended or ceiling-mounted. Presumably, the relationships of floor and wall lumens were based on this condition. In their reported tests, however, it is the ceiling height, rather than the mounting height, which is always taken as four times the work-plane height. Then, when units are suspended as much as one-third the distance to the work-plane, one would expect that not only the lumens directly delivered to the work-plane but the relationship of floor and wall lumens to work-plane lumens would be different. Perhaps the authors have employed other (or unpublished) zonal multipliers and ratios for the test conditions. This information would facilitate a decision as to the importance of any of these conditions, and whether there is any effect on how well measured and calculated data agree.

1. An Illumination Recorder, A. H. Taylor and W. G. Pracejus, ILLUMINATING ENGINEERING, Vol. XLVI, p. 310 (1951).

DOMINA EBERLE SPENCER*: If Jones and Neidhart wish to verify the accuracy of their zonal method of using the interflection method, should they not employ some of the *modern luminaires* that are mentioned in the introduction of their paper? With bare lamps and RLM reflectors it is undoubtedly satisfactory to use candlepower curves for calculating the fraction of the luminaire output to walls, ceiling, floor and principal surface. But what about *modern luminaires?* Where is the test which shows that the Jones-Neidhart method of treating 8-foot luminaires as point sources is valid?

The experimental procedures seem to be carefully carried out and the curves derived from the interflection data appear reasonable in shape. But why do the authors cling to the 14 per cent floors of 1915?

In their discussion of the data with silver-bowl lamps, for which the largest discrepancies appear, Jones and Neidhart blame their low values on the basic interflectance tables. They say that the "ceiling interflectance values are considered by the authors of the Interflectance Method to be slightly conservative for high narrow rooms."

In comment I should like to point out that the discrepancy between the zonal curve and the experimental curve is present in both large and small rooms! It may also be of interest to note that a better fit of the Jones-Neidhart data can be obtained without any zonal nonsense by merely using the values for ceiling lighting Type IIb in Table 5.03 of *Lighting Design* ($\rho_1 = 0.50$, $\rho_2 = 0.75$, $\rho_3 = 0.10$). The results are shown in Fig. D-1 (of this discussion). The smooth curve is obtained from Table 5.03. The Jones-Neidhart experimental data are represented by circles. These tables in *Lighting Design* are the ones on which the Jones-Neidhart method is supposed to be based. Does the complex zonal process devised by Jones and Neidhart devour lumens, or where did they go to?

Because of the approximations made in the solution of the basic integral equations of the interflection method, one would expect the resulting values of interflectance to be conservative, if anything, at high values of k_r. However, these "conservative" tables for ceiling lighting have been verified with unexpected accuracy both by Churchill and Putnam and by Jones and Neidhart themselves!

*University of Connecticut, Storrs, Conn.

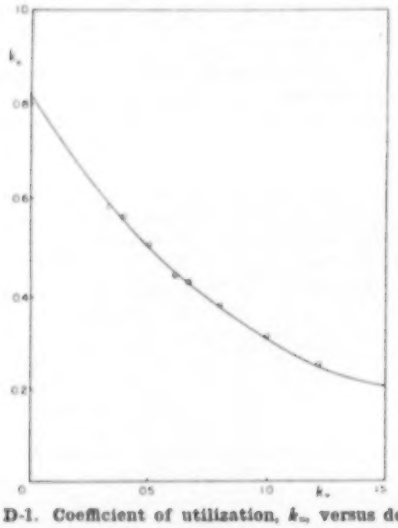


Figure D-1. Coefficient of utilization, k_u, versus domance, k_r. The curve is a simple application of the interflection method to ceiling lighting. Circles represent Jones-Neidhart experimental data in rooms using silver-bowl lamps. Agreement is excellent. Note the much larger discrepancies shown in Fig. 4 (of paper) based on the zonal method of employing the same basic interflectance tables.

J. R. JONES and JOHN J. NEIDHART*: The authors thank Mr. Potter and Dr. Spencer for their comments and for calling attention to points requiring clarification.

Although it is true that the multicell instrument which we used has a small cosine error at high angles, it is doubtful that any significant error in the data resulted in the rooms used for the tests. This is indicated by the close agreement between our data and that of Potter and Russell which was obtained with the more closely corrected test cell to which Mr. Potter referred.

Mr. Potter's other comments are confined to a discussion of the deviations between the tested installation conditions (mounting height, suspension distance, work plane location, etc.) and the conditions that were assumed in designing the Zonal Interflectance method of calculating coefficients. The authors have stated previously and wish to emphasize again that for the purpose of making exact comparisons between measured and calculated values, the conditions in the test installation should duplicate those assumed in the calculations. Unfortunately, testing facilities must be extremely flexible to duplicate these conditions over a wide range of room sizes and shapes. Our facilities were not that flexible so some deviations from the assumed conditions were necessary. Obviously these deviations occur in practice as well as in the laboratory. That Mr. Potter had similar experiences is evidenced by the cross plotting of data and special calculations reported in his own paper. (Potter, W. M. and Russell, A. H., "Measured Utilization Factors," page 137.) The calculated utilization coefficients we reported were not based upon special computations or on any new factors.

The selection of a constant 4½-foot spacing for all of the tests reported was purely a matter of being practical. It is essential that the luminaire arrangement be perfectly symmetrical in each of the two room sizes, and the only practical symmetrical arrangements result in either four or nine luminaires in each 9 x 9-foot quadrant. Tests for the silvered bowl and general service lamps were made with both four and nine lamps in the 9-foot square room, and coefficients were calculated for spacing to mounting height

*Authors.

ratios varying from 0.6 to 1.0. Both the tests and the calculations showed that the variation in spacing had little effect upon the coefficients of utilization for these types of distribution; and the data were, therefore, omitted to comply with space limitations. This does not indicate, however, that Zonal Multipliers for different spacing to mounting height ratios are unnecessary. They are important for narrow distribution luminaires that must be spaced relatively closely. The use of Zonal Multipliers for a 1.0 spacing to mounting height ratio in calculating coefficients for a luminaire whose spacing should not exceed 0.6 times the mounting height would result in coefficients that are several per cent too high.

The authors noted too the discontinuity of the measured data (See Table V) that is published as a smooth curve in Figs. 6 and 8. Mr. Potter has suggested that this is caused by a varying ratio of suspension distance to ceiling height above the work plane. Calculations show that Mr. Potter's explanation accounts for approximately half the discontinuity in the case of Fig. 6. The room ratio against which the measured coefficients were plotted applies strictly only to a totally direct luminaire recessed *into* the ceiling. The general service lamp was neither totally direct in distribution nor recessed into the ceiling. The RLM Deep Bowl luminaires were direct, but they were not recessd and calculations do not indicate that the varying suspension ratio is a significant contributor to the discontinuity in Fig. 8. Rather than plot a discontinuous curve in the paper, accompanied by a partial, but complex, explanation based on a criticism of the room ratio system, the authors published a smooth curve. Thus, in Fig. 8, the worst case, one point at a room ratio of 1.21 was 3½ per cent above the curve, the other 3½ per cent below the curve.

Mr. Potter's question regarding our selection of work plane location is valid, but he and Mr. Russell have answered his question in Table I of their own paper, "Measured Utilization Factors" where they show that changing the work plane height from 15 inches to 30 inches had virtually no effect in rooms having ceiling, wall, and floor reflectances matching those used in our test rooms.

Dr. Spencer has asked why we did not employ more modern luminaires in our tests. The reasons for the selection of the simple luminaires that were employed are given in the text of our paper. Lack of time prevented us from continuing our tests with luminaires more typical of those in current use, but such tests will be made to prove the validity of the Zonal-Factor Interflectance Method for large area luminaires. One of the "modern" distributions to which we have repeatedly referred and which was really our reason for developing the Zonal Method is the narrow distribution, characteristic of some high bay luminaires and reflector lamps. The accuracy of the Zonal Method for such distributions had already been proven by Potter and Russell, and it seemed unnecessary to duplicate their work.

Although we have no particular liking for a 14 per cent floor reflectance, we believe that Dr. Spencer must admit that they are much more likely to be found in practice than the 30 per cent floor reflectance that we all like to recommend. Our data up to this point have been based upon a 14 per cent floor reflectance primarily to facilitate comparison with the Three Curve Method. Zonal-Factor Interflectance curves for a 30 per cent floor reflectance were provided in our paper last year (Jones, J. R., and Neidhart, John J.: "The Zonal Method of Computing Coefficients of Utilization and Illumination on Room Surfaces," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 3, p. 141, March 1953), and all of our curves have since been revised to correspond with the latest ceiling, wall, and floor reflectances that are recommended by the Illuminating Engineering Society for use in preparing coefficient of utilization tables. These include floor reflectances of 10 and 30 per cent and permit interpolation for a 20 per cent floor reflectance.

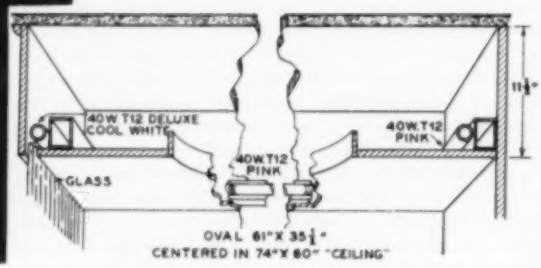
With reference to Fig. 4, Dr. Spencer points out that our discrepancy between the measured and calculated Zonal Method curves exists in all room sizes. It should be noted, however, that the deviation varies from 15 per cent in high narrow rooms to only 5 per cent in large ("C" index) rooms. This is the basis for our statement that the basic Interflectance Method may be at least partly to blame for the larger deviation in high narrow rooms.

Dr. Spencer's curve is interesting, but it is also misleading. Her comments and her curve might lead the casual reader to conclude that the zonal process actually is nonsense. Her curve gives a utilization factor that is based on the assumption that the light emitted by the silvered bowl lamps (of Fig. 4) is *all* directed to the ceiling and *none* to the walls. To assume that all the light strikes the ceiling when the lamps are suspended as far as 2¾ feet below the ceiling in a room only 9 feet square is ridiculous. Detailed calculations show conclusively that *over half* the lumens strike the wall in some of the test installations. The interflectance method provides interflectance factors for both walls and ceiling. Obviously both factors should be used. The writers wish to emphasize that we believe Dr. Spencer presented her curve merely as an interesting (and, in our opinion, meaningless) coincidence and we are certain she does not wish to infer that anyone should apply the interflectance method in the haphazard manner suggested by her curve.

The zonal process does not devour lumens, but rather, is used only to determine from conventional photometric data the number of lumens that are directed (as in the case of Fig. 4) to the ceiling and to the walls. The lumens directed to the ceiling are multiplied by Dr. Spencer's f_2 factor and the wall lumens by the f_1 factor. The sum of these two products is the lumens from these lamps that ultimately reach the work plane.

Revised Committee listing to be in April I.E.

INSTALLATION IN
CLEVELAND HEIGHTS, OHIO.



Lighting a Small Reception Area

LIGHTING OBJECTIVE: To provide an unusual lighting treatment which would be flattering to guests and provide a decorative element in an entrance hall.

GENERAL INFORMATION: An area 5 feet by 6 feet 2 inches is set apart from the living-dining room by means of a floor-to-ceiling fluted glass panel. The ceiling in the entire room is 8 feet high and is of white plaster. All walls are paneled in Philippine mahogany (30 per cent reflectance) and the floor carpeting is blue gray (20 per cent reflectance).

INSTALLATION: A false ceiling of the Philippine mahogany paneling was dropped 11½ inches below the actual ceiling in this reception area. An oval coffer approximately 3 feet by 5 feet was formed in this false ceiling. Four 40-watt fluorescent lamps indirectly light this area to five foot-candles. One of the channel strips is turned toward the outside of the cavity so that the tube is directly over the fluted glass panel which serves as a divider between the reception and dining areas; thus it lights the panel as well as contributing to the coffer lighting.

One blue and two pink lamps were chosen both for their relation to the basic color scheme in the room and for their blend with the one deluxe cool white lamp to yield a color of light which is hospitably warm and subtly flattering to guests.

The white ceiling of this coffer is not visible from normal viewing positions in the living room — only the mahogany paneled vertical surface. Its brightness is 35 footlamberts.

Architect: George A. Letts, Cleveland, Ohio.

Lighting data submitted by Miss Aileen Page, Residence Lighting Specialist, General Electric Lamp Division, Nela Park, Cleveland, Ohio as one solution of a lighting problem and to aid in the design of similar installations.

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Measured Utilization Factors

By WENTWORTH M. POTTER
ANSON H. RUSSELL

Utilization factors for a variety of room conditions and types and numbers of luminaires have been determined by the authors. Highly flexible laboratory facilities previously described in ILLUMINATING ENGINEERING were employed. Values for selected conditions are presented in charts and tables. They are compared with utilization factors from empirical and calculated data. The value of flux-ratios is pointed out and explorations of uniformity are included.

IN A previous paper,[1] the authors reviewed the status of illumination design information and the needs for data which would enable the designer and application engineer to plan installations with greater confidence.

One of the most important kinds of information is that on utilization of light. In this field, one needs a consistent and reasonably accurate system of data which takes account of room conditions, luminaire distribution, and the practical conditions of installation. The empirical data of Harrison and Anderson[2,3] have served well, and their characteristics and limitations are well known. The Interflection Method of Moon and Spencer[4,5] is a valuable contribution to this subject, and it has been extended[6] to a variety of specific mathematical distribution curves. Coradeschi and Innis[7] and Jones and Neidhart[8,9] have made contributions to the technique of employing the interflection method, particularly as applied to luminaires. Our objective has been to measure utilization as accurately as possible for a wide variety of room conditions, candlepower distributions and luminaire arrangements, and to compare the results with other data. For measurements, we have utilized the flexible laboratory facilities and instrumentation reported previously.[1]

Such measurements involve not only the actual searching or sampling of the work-plane, but important calibrations of the test equipment for absolute response and linearity. Sources and luminaires were carefully matched for distribution and operated at equal outputs. Additional periodic photometric tests of their output and distribution were made. Supplementary checks were made for symmetry; when necessary, units were rotated (Fig. 1). Lamps were carefully checked for com-

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHORS: Application Engineering Department, Lamp Division of General Electric Company, Nela Park, E. Cleveland, Ohio.

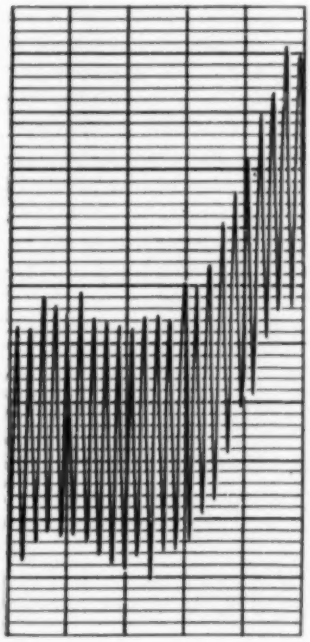

Figure 1a. (left) Oscillations in the candlepower distribution curve of the luminaire shows that output varies around the axis of rotation. In utilization tests, such irregularities may cause error in the amount of light delivered to the planes of interest.

Figure 1b. (right) Rotating complete luminaire during utilization tests assures average distribution of output. This device is flexible as to fixture suspension, provides power and voltage connections. Powered by a small synchronous inductor motor with shaft speed of 75 rpm.

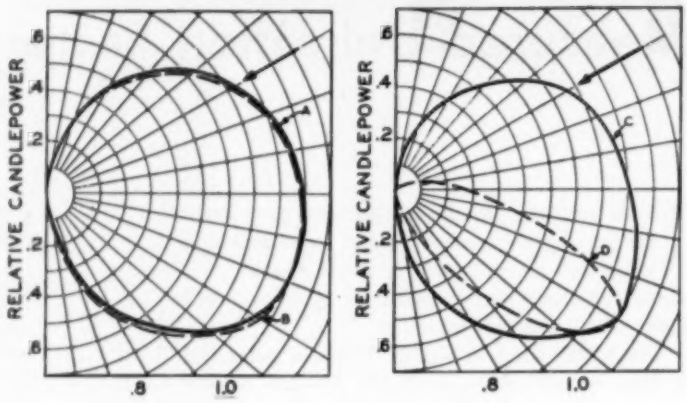

Figure 2. The character of distribution of reflected light from typical room surface finishes is shown plotted with maxima at 1.0 regardless of total reflectance. Incident light is in the vertical plane with respect to wall surfaces as installed. Collimated illuminating beam was incident at 30 degrees. Total reflectances are: (A) White (for ceilings) 0.82; (B) Light Gray (for ceilings and walls), 0.50; (C) Dark Gray (for ceilings, walls and floors, 0.19; (D) Black (for ceiling and floors), 0.04.

plete stability of output because they were to be handled repeatedly. These were some of the measures that were required for accuracy.

Careful measurement of the total reflectance of each room surface is necessary so that utilization tests can be correlated properly and compared with calculated data which assume precisely known reflectances.[1] Accurate values are most important in the case of ceilings and walls; in indirect lighting all the utilized flux is reflected from these surfaces.

After consideration of other devices and methods, the portable Baumgartner Reflectometer[10] was chosen for these measurements, and our particular instrument was carefully checked. Measurements were made at numerous stations on room surfaces.

Reflectance values used in utilization tests ranged up to 0.83 for ceilings, 0.50 for walls, and 0.40 for floors. Surfaces were checked periodically for depreciation, and repainted when needed. When desired, floors were adjusted to an exact average reflectance (*e.g.*, 0.14) by using numerous uniformly distributed areas of a different reflectance. In this paper, reflectances are given in the order: ceiling—walls—floor, *e.g.*, 0.80—0.50—0.14.

Surface finishes with a specular component would be expected to increase utilization slightly as compared with matte finishes, as in the case of louver cells.[11] The higher reflectance lacquer finishes used thus far in our tests exhibited little directive effect. The characteristics of typical finishes, determined with a recording goniophotometer, are shown in Fig. 2. Finishes were essentially neutral spectrally.

Direct Lighting

Extensive tests of direct lighting with several different candlepower distributions were made in a 12½-foot-square room. Room ratios were varied from 0.6 (J) to 2.0 (E) by changing ceiling height. A wide range of room surface reflectances, fixture positions, fixture suspensions and work-plane heights were among the variables investigated.

Four units were used to facilitate photometry and control for equal lamp output. They also presented typical obstruction of ceiling (constant percentage of ceiling area for all room ratios). Six different arrangements of the four fixtures were selected so that cross-plotting made it possible to obtain weighted average utilization factors[12] for any number of units in the room. Checks on validity of this procedure were made with luminaires in special patterns allowing direct averaging for an installation of 16 units.

Many direct comparisons for a variety of candlepower distributions and surface reflectances were made to study the effect of changing work-plane height at the same room ratio. This was necessary because some test rooms were at reduced scale. The results, samples of which are shown in Table I, indicate that the differences are usually less than one per cent except for high floor reflectances.

TABLE I.—Effect of Change in Work-Plane Height for Constant Room Ratio.

(Square room, width = 12.5′. Work-plane heights — 30″ and 15″. Four RLM Dome luminaires in six different ceiling patterns, units suspended 12″.)
Per cent change caused by reduction of work-plane height from 30 to 15 inches. Reduction of height is in effect a change of scale and proportions of space below the work-plane. Each value represents an average of six comparisons with different ceiling patterns.

Reflectances: Ceiling	0.82					
Walls	0.48			0.19		
Floor	0.39	0.14	0.04	0.39	0.14	0.04
Per Cent Difference at Room Ratio 2.0*	+1.6	−0.1	−0.9	+2.3	+0.7	0.0

*Maximum effect was to be expected at this room ratio, the highest employed in these tests.

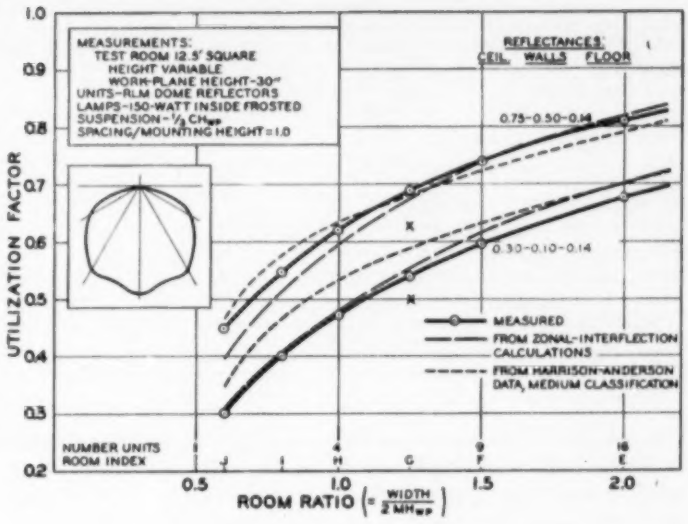

Figure 3. Test data are compared with values derived from published data at two reflectance combinations. Comparisons are made on the same basis of fixture suspension, and on a 1.0 spacing-to-mounting height ratio, except that Harrison-Anderson data do not specify numbers of units. A 0.4 spacing-to-mounting height ratio displays the same relationship between test and calculated data, but the actual values are lower. Utilization factors for the two reflectance combinations as calculated from Moon and Spencer's data for a cosine distribution are indicated by X for a room 10 feet high with $k_r = 0.8$.

Wide Distribution

One of the output distributions chosen for tests with a variety of reflectance patterns was the well known RLM Dome for filament lamps. This unit provided excellent symmetry of distribution, and curve shape (Fig. 3) which was within the range of the original Harrison-Anderson data. The flux ratio[13] was 0.43, almost in the center of their "Medium" classification. The units were 14 inches in diameter, and 150-watt lamps were used. The general tests were made with a ceiling-to-light center distance of 12 inches. Surface reflectances used: ceilings, 0.80, 0.40, 0.05; walls, 0.50, 0.20; floors, 0.40, 0.14, 0.05.

Measured utilization data are compared in Fig. 3 with values from two sets of published data[3, 9] for two widely-separated combinations of reflectance. For this chart a spacing-to-mounting height (above work-plane) ratio of 1.0 was chosen, although it is recognized that similar distributions are often employed at lower ratios. Test data were cross-plotted to give the values applicable to the number of units indicated in this chart. In addition the test data were adjusted, on the basis of supplementary tests, for a suspension of one third of ceiling height above the work-plane. The Harrison-Anderson and zonal multiplier-interflection data are both taken from their sources without modification. At the higher reflectances, the calculated data are somewhat lower in the taller, narrower spaces. In this range the test rooms were essentially full scale.

We desired to obtain more exact correlation between calculation and individual, unadjusted tests. For this purpose, zonal multipliers, by 5-degree zones, for both work-plane and floor, were computed[14] for the simple pattern of four regularly spaced units. This was done for several room ratios. These multipliers were then used with "f" factors, specially calculated for exact test room conditions, in the following equation:

$$\text{Utilization Factor} = \text{Direct Ratio} + (1.0 - \text{Direct Ratio})\frac{k}{k'}f_1 + (\text{Floor Ratio})\,f_3$$

Where: Direct Ratios and Floor Ratios are the fractions of output directly incident on work-plane and floor as individually calculated for the same number of units.

k = ceiling to floor distance.

k' = ceiling to work-plane distance (CH_{wp}).

f_1 and f_3 = wall and floor interflectance factors. For f_3, 1.0 is subtracted.

This equation assumes that the average brightness of the entire wall is the same as that above the work-plane. The results of several such calculations are tabulated with directly measured values in Table II. Agreement is within four per cent.

Narrow Distributions

Tests on narrower candlepower distributions, ranging in flux ratio from 0.77 to 0.98, were made at one set of reflectances: 0.80—0.50—0.19. For this purpose, reflector flood lamps were used in six-inch cylinders recessed in the ceiling. Lamps were adjustable in height so that shielding angles[15] of 0° (bulb flush with opening of cylinder), 15°, 30°, and 45° could be employed. Distributions in this range of concentration, although far beyond the present extrapolations,[16] are frequently encountered in practice.

Measured and calculated utilization factors for

TABLE II.—Measured and Calculated Utilization Factors—Wide Distribution.

(Test units: 14″ RLM Dome with 150-watt inside frosted lamp. Calculations based on exact test room conditions. Square room, width = 12.5′. Reflectances: ceiling, 0.80; walls, 0.50 and 0.20; floor, 0.14. Four units, spaced 75″, suspended 12″.)

Room Ratio	0.6 (J)		1.0 (H)		2.0 (E)		2.0 (E)	
Work-Plane Height	30″		30″		30″		15″	
k_r	1.112		0.780		0.530		0.430	
h'/h	0.820		0.744		0.623		0.768	
Direct Ratio*	0.2819		0.4602		0.7485		0.7485	
Floor Ratio*	0.2089		0.3312		0.5108		0.6176	
Refl.: Walls	0.50	0.20	0.50	0.20	0.50	0.20	0.50	0.20
"f_1" (wall)**	0.1769	0.0510	0.2216	0.0667	0.2610	0.0828	0.2956	0.0967
"f_2" (floor)**	0.0245	0.0084	0.0337	0.0152	0.0493	0.0294	0.0566	0.0353
Calculated U.F.	0.442	0.328	0.632	0.514	0.879	0.797	0.880	0.802
Measured U.F.	0.433	0.317	0.631	0.515	0.863	0.767	0.859	0.772
Diff. in per cent***	+2.1	+3.2	+0.2	−0.2	+1.8	+3.8	+2.3	+3.7

Effective wall ratio taken as (1.0 — Direct Ratio) h/h'.
*Fractions of output directly incident on work-plane and floor. Each ratio calculated separately, based on special zonal multipliers for 5-degree zones, from general equation in Appendix.
**Specially calculated "f" factors for surface reflectances and exact room dimensions. For floor, 1.0 has been subtracted.
***Difference between measured and calculated factors in per cent of the former.

selected narrow distributions are shown in Fig. 4. A curve of Harrison-Anderson values, as extrapolated to the "Focusing" classification, is included to show the error introduced by applying these factors for extremely narrow distributions. Calculated values are derived from published zonal multipliers and interflectance factors[5] for reflectances: 0.80—0.50—0.19, with a ceiling height of ten feet and a work-plane height of 30 inches. It will be noted that agreement with test results is excellent. This conclusion is confirmed, in general, by the more exact comparisons shown in Table III.

TABLE III.—Measured and Calculated Utilization Factors—Narrow Distributions.

(Test units: ceiling recessed black cylinders, 6″ diameter, with 150-watt R-40 Flood lamps. Calculations based on exact test room conditions. Square room, width =12.5′. Work-plane height — 30″. Reflectances: ceiling, 0.80; walls, 0.50; floor, 0.19. Four units, spaced 75″, recessed in ceiling.)

Room Ratio	0.6 (J)				1.0 (H)	2.0 (E)		
k_r	1.032				0.700	0.450		
h'/h	0.807				0.715	0.555		
"f_1" (wall)*	0.1927				0.2234	0.3240		
"f_2" (floor)*	0.0357				0.0517	0.0789		
Shielding Angle	0°	15°	30°	45°	0°	0°	15°	30°
Direct Ratio**	0.532	0.591	0.669	0.764	0.736	0.951	0.970	0.988
Floor Ratio**	0.419	0.485	0.569	0.667	0.598	0.778	0.836	0.905
Calculated U.F.	0.659	0.705	0.768	0.844	0.849	1.036	1.054	1.066
Measured U.F.	0.652	0.690	0.748	0.788	0.855	1.040	1.056	1.067
Diff. in per cent***	+1.0	+2.1	+2.6	+6.6	−0.7	−0.4	−0.2	−0.1

Effective wall ratio taken as (1.0 — Direct Ratio) h/h'.
*Specially calculated "f" factors for surface reflectances and exact room dimensions. For floor, 1.0 has been subtracted.
**Fractions of output directly incident on work-plane and floor. Each ratio calculated separately, based on special zonal multipliers for 5-degree zones, from general equation in Appendix.
***Difference between measured and calculated factors in per cent of the former.

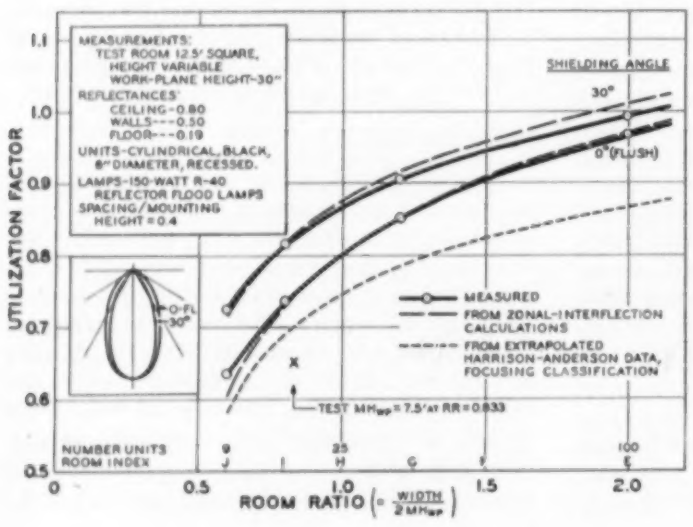

Figure 4. Test data for two shielding angles, derived from cross-plots of measured values for various luminaire patterns, are shown with data calculated from published zonal multipliers and interflectance factors. Harrison-Anderson data for the "Focusing" classification is also included. The utilization factor, calculated from Moon and Spencer data,[6] for a distribution in which the candlepower varies as $\cos^3$ is 0.65, indicated by X in the chart. This is for a room 10 feet high with $k_r = 0.8$.

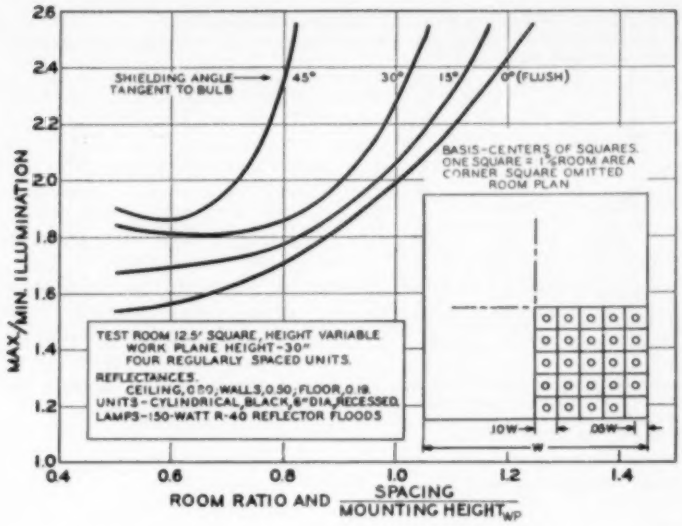

Figure 5. Variation of work-plane illumination produced by several narrow distributions. Readings for maximum and minimum values taken at test stations shown in inset.

For such narrow distributions, it was desired to analyze test data as to uniformity of illumination. Recorded curves made it easy to explore variations; maximum and minimum values in the measured quadrant could be read or interpolated. The simplest approach involved the use of four regularly spaced units, with spacing-to-mounting height ratio changing with ceiling height.

For this purpose, one quadrant of the work-plane was divided into 25 squares and values at the center of each square were derived from curves. The corner square was omitted because it was considered an extreme value.

Fig. 5 indicates the variation in illumination (maximum/minimum) which was found under these conditions, as room ratio and spacing ratio were changed. For example, variation of two to one is found at spacing-to-mounting height ratios of about 0.7 in the case of 45° shielding and 1.0 for 0° shielding. In many cases in practice, the illumination values would call for closer spacing of units.

Medium Distribution

For another series of direct lighting tests, the 750-watt R-52 integral-reflector lamp was selected. It lies between the former units in spread; with a flux-ratio of 0.67, it is slightly more concentrated than the "Focusing" classification. Four lamps selected for consistent curve shape were used in various patterns at suspensions of 12 and 30 inches from ceiling to light center. Lamp necks were covered to eliminate upward light. To guard against error due to asymmetry of output about the physical axis of the lamps, they were rotated at 75 rpm during tests. Data were carefully cross-plotted and weighted for the effect of additional

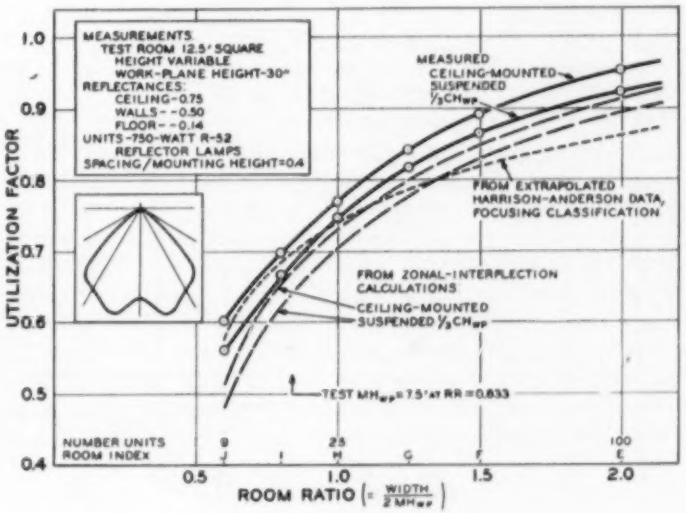

Figure 6. Measured utilization values for R-52 lamps at two suspensions compared with those derived from two sets of published data. Differences between measured and calculated values for like suspension conditions are significant at the lower room ratios and decrease in percentage in wider rooms. Tests with lower work planes indicated measured values at larger room ratios are slightly conservative. Strictly, the Harrison-Anderson "Focusing" classification factors apply only for the suspended unit condition. In 0.6 (J) and 0.8 (I) rooms they are based on one centrally located unit instead of nine. Recognizing this difference there is a satisfactory check at these points with Lighting Facilities Laboratory measured data.

TABLE IV.—Measured and Calculated Utilization Factors—Medium Distribution.

(Test units: 750-watt R-52 reflector lamps. Bat-wing shaped candlepower distribution. Calculations based on exact test room conditions. Square room, width = 12.5′, ceiling height variable. Floor reflectance, 0.14.)

Room Ratio	0.6 (J)	0.6 (J)	1.0 (H)	1.0 (H)	2.0 (E)	2.0 (E)	2.0 (E)	2.0 (E)
Work-Plane Height	30″	30″	30″	30″	30″	30″	30″	15″
Number of Units	4[1]	9[2]	4[1]	4[1]	100[3]	16[2]	16[2]	4[1]
Suspension	30″	30″	12″	12″	30″	12″	12″	30″
Refl.: Ceiling	0.82	0.82	0.80	0.50	0.82	0.80	0.80	0.82
Walls	0.50	0.50	0.50	0.20	0.50	0.50	0.20	0.50
Direct Ratio[a]	0.431	0.400	0.635	0.635	0.779	0.800	0.800	0.915
Floor Ratio[a]	0.307	0.302	0.494	0.494	0.715	0.755	0.755	0.789
k_r	1.333	1.233	0.780	0.780	0.650	0.530	0.530	0.550
k'/k	0.838	0.838	0.743	0.743	0.692	0.623	0.623	0.818
"f_1" (wall)[b]	0.1634	0.1634	0.2216	0.0580	0.2695	0.2610	0.0828	0.2792
"f_2" (floor)[b]	0.0232	0.0232	0.0337	0.0110	0.0416	0.0493	0.0294	0.0478
Calculated U.F.	0.549	0.525	0.762	0.669	0.894	0.921	0.849	0.981
Measured U.F.	0.586	0.577	0.791	0.708	0.920	0.958	0.885	1.010
Diff. in per cent[c]	6.3	9.0	3.7	5.5	2.8	3.8	4.1	2.8

Effective wall ratio taken as (1.0 — Direct Ratio) k/k'.

[a] Fractions of output directly incident on work-plane and floor. Zonal multipliers for the four-unit system were calculated separately for work-plane and floor, using general equation in Appendix. For other numbers of units, published multipliers were used.

[b] Specially calculated "f" factors for surface reflectances and exact room dimensions. For floor, 1.0 has been subtracted.

[c] Difference between measured and calculated factors in per cent of the former.

[1] Measured in a single test of four units.

[2] Direct average of three tests.

[3] Weighted average of utilization factors obtained by cross-plotting by location.

numbers without undue obstruction of the test space.

For this bat-wing shaped distribution, so often desirable for industrial lighting, measured and calculated data do not agree as well as for other direct types. Fig. 6 indicates that the former exceed values from published zonal factor-interflection data by as much as 14 per cent in rooms of low ratio. At higher ratios the relative difference decreases.

This trend was checked for certain test conditions with interflectance factors specially calculated from the equations. Zonal multipliers were also calculated for the four-unit examples. Comparisons of calculated and measured data are presented in Table IV.

The calculations of Table IV include the correction for wall-incident output described in connection with the wide distribution above. Although this tends to increase the values in this case, differences as high as 9 per cent remain at the 0.6 room ratio, and smaller differences at larger ratios.

Part of these differences should be attributable to non-uniformity of wall brightness. Units of this kind direct considerable light to the lower wall area (above the work-plane) and light reflected will be utilized better than from areas high on the walls. Hence, test results are higher than calculated values based on uniform wall brightness.

What About Flux Ratio?

The current concept of flux ratio has been criticised because it seemed an inadequate index to utilization for many narrow distributions used to-

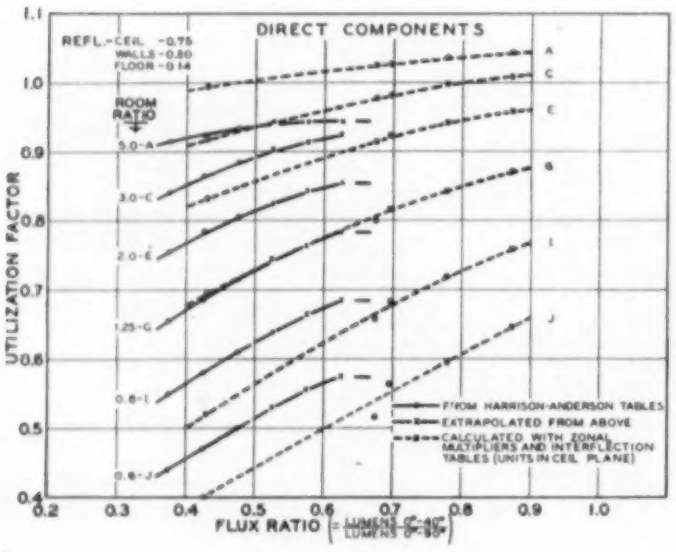

Figure 7. Chart of utilization factors plotted against 0°-40°/0°-90° flux-ratio indicates how calculated factors extend over a wider range than those from present tables. Use of "Focusing" classification (flux ratio = 0.625) for all narrower distributions gave values sometimes higher, sometimes lower, than calculated data. (Calculated factors are based on S/MH_w of 0.4).

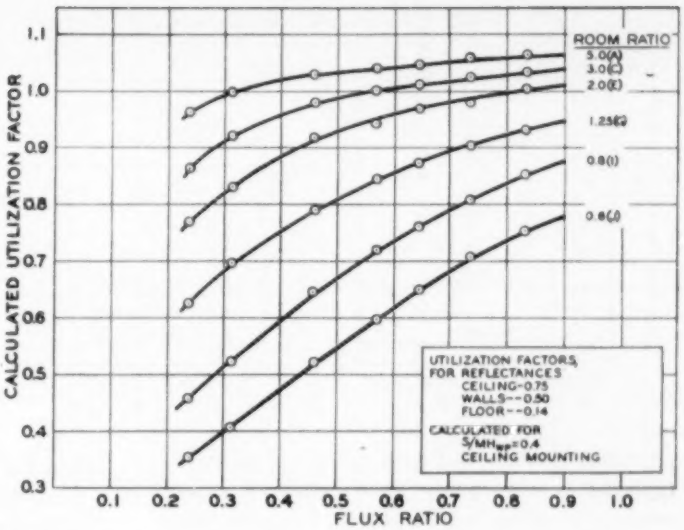

Figure 8. Many calculated utilization factors, for candlepower curves of considerable variety, fall quite well into curve form when plotted against a special form of flux ratio. The highest flux ratio shown is equivalent to a 0°-40°/0°-90° flux ratio of about 0.98. The special flux ratio (abscissa) is the sum of fractions of 0°-90° output in the specified zones multiplied by the following tentative weights:

Fraction in 0°-20° zone $\times$ *1.00*
Fraction in 20°-30° zone $\times$ *0.65*
Fraction in 30°-40° zone $\times$ *0.30*
Fraction in 40°-50° zone $\times$ *0.20*
Fraction in 50°-60° zone $\times$ *0.10*

day. The distributions in question are much more concentrating than those included in the original Harrison and Anderson data and its subsequent extrapolations. A major source of error in dealing with such distributions is the use of the "Focusing" classification (0.60-0.65) for all more concentrated distributions. Actually, as Fig. 7 indicates, the 0°-40°/0°-90° flux ratio serves reasonably well as an index to concentration up to the region of 0.85.

Flux ratio is a single number intended to describe the degree of concentration. By its use, a general picture of direct utilization and the relationship of one distribution to another may be clearly presented. Moreover, it permits rapid determination of the performance of direct distributions.

A still wider range of concentration could be handled reasonably well by two definitions of flux ratio: 0°-40°/0°-90° ratio and 0°-20°/0°-90° ratio, the latter sensitive for very concentrated distributions. Possibly a different expression for flux ratio, such as that suggested by Mr. Phelps Meaker and used in Fig. 8, will serve the purpose.

Indirect Lighting and Upward Components

Indirect lighting remains an important technique of illuminating engineering; in fact, the performance of upward components of luminaire output is of increasing interest in various fields, including industrial lighting. Recently, coefficients higher in practice than indicated by design data in the *I.E.S. Lighting Handbook* have been reported.[17] Some of these differences may be attributable to failure to allow for higher reflectances[18] than presented in the usual table. In some cases, a minor direct component was neglected. But differences have remained, suggesting that more exploration is needed. Accordingly, we have measured utilization factors for certain indirect units in a variety of conditions. These tests indicate that candlepower distribution, suspension distance, and number of units in a room are all important factors.

A logical basis for indirect lighting data involves first a practical number of units. Accordingly, we have chosen a minimum of four in rooms of ratio[19] 0.75 and up to nine units for room ratio 1.5 (F). Tests thus far, with up to four units at a time, have been in this range of room ratio to avoid too small room dimensions; further check tests in rooms 30 feet square are planned. Moreover, suspension distance in actual installations should not be chosen necessarily as $\frac{1}{3}CH_{wp}$, but rather on the basis of distribution of ceiling brightness and appearance of the room. For tests in our rooms, suspension distances of 23 inches and 16½ inches were selected for four- and nine-unit systems, respectively. Vertical cross-sections of two test rooms showing the principal positions of units are illustrated in Fig. 9.

We regard the ratio of spacing-to-suspension distance as an index important in determining the amount of light originally incident upon the ceiling. Within limits this may be independent of room ratio. The above choices of numbers of units and suspension distances result in values of this ratio of about 3.0 to 3.25. This is suitable for the silvered bowl luminaire used in most of the tests to date and is reasonably representative of practice. With 23-inch suspension distance in a room of ratio 0.75, there is a maximum-to-minimum variation of three to one in ceiling brightness. The 23-inch and 16½-inch suspension distances represented 15 and 22 per cent of ceiling-to-work-plane distance, respectively.

For the principal tests, we desired a luminaire

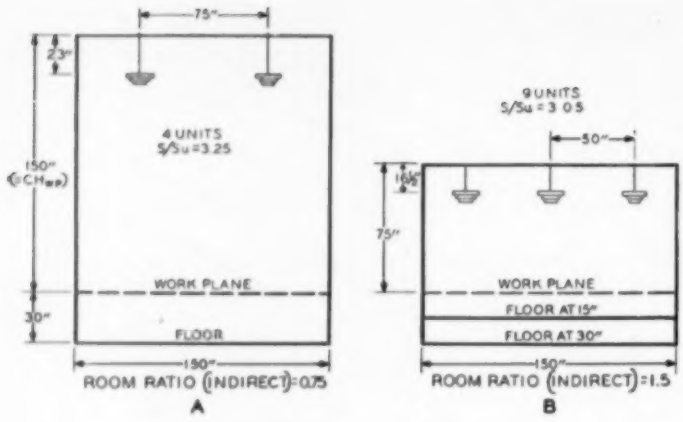

Figure 9. Vertical cross-sections of two of the rooms used for indirect lighting tests with various numbers of units and suspension distances.

providing only upward light in a wide distribution typical of a silvered bowl lamp. Minimum obstruction of the ceiling consistent with this requirement was secured by choice of a three-concentric-ring louver unit 14 inches in diameter. The inside surfaces of the rings were blackened to prevent reflection of light downward from the lamp, but the outer surfaces were white to absorb as little light from the ceiling as possible. The candlepower distribution is shown in Fig. 10. Gross area of each unit was 0.68 per cent of ceiling area of the 12½-foot-square room.

Utilization factors as measured for selected conditions with these units are plotted in Fig. 10. Also included are values calculated with published zonal multiplier-interflection data for ceiling-mounted and suspended conditions, and a curve from the Harrison-Anderson utilization data. Numbers of units and suspension distances differ among these curves, but calculated values corresponding to the suspension-to-ceiling height (above work-plane) ratio used in tests would fall nearly midway between the calculated curves (A) and (B).

At larger room ratio values measured utilization factors are substantially higher than the Harrison-Anderson curve, a result probably due to the much better cosine-correction of test cells, and, therefore, more accurate evaluation of light incident on the work-plane at wide angles. The variable error caused by imperfect cosine correction was recognized by Harrison and Anderson; Dr. Harrison has recently[20] pointed out that conservative values were regarded as desirable in view of the performance of typical measuring instruments and the reductions in illumination due to such factors as obstructions, including people.[21]

Calculated values are lower than test results in low ratio rooms, with less difference as rooms become larger. This is confirmed by the more exact calculations summarized in Table V. Approximations in the mathematical treatment may account for some of the difference in high narrow rooms. Variation in ceiling brightness is also a factor. Calculated utilization values apply for a uniformly

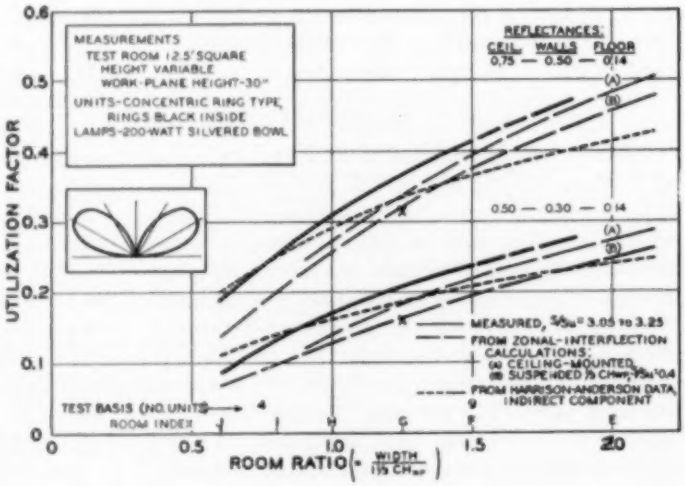

Figure 10. Measured utilization factors for two combinations of reflectance, for spacing-to-suspension ratio of 3.05 to 3.25 are given in the solid curves. Other curves are derived from two sets of published utilization data. Note that they are based on other conditions as to suspension and number of units. Utilization factors for the two reflectance combinations as calculated from Moon and Spencer data for an indirect cosine distribution are indicated by X for a room 10 feet high with k_r equal to 0.8. The calculated utilization factors do not include an allowance for obstruction of the ceiling.

TABLE V.—Measured and Calculated Utilization Factors—Silvered Bowl Indirect.

(Test units: three concentric rings, finished black inside. Calculations based on exact test room conditions. Square room, width = 12.5'. Work-plane height — 30". Reflectances: ceiling, 0.80; walls, 0.50; floor, 0.14.)

Room Ratio	0.75	0.9	0.9	1.2	1.2	1.5
Number of Units	4	4	9	4	9	9
Spacing/Susp. (S/Su)	3.25	3.25	3.05	3.25	3.05	3.05
Ceiling Ratio*	0.746	0.746	0.807	0.746	0.807	0.807
k_r	1.200	1.033	1.033	0.825	0.825	0.700
"f_1" (wall)**	0.1667	0.1867	0.1867	0.2152	0.2152	0.2340
"f_2" (ceiling)**	0.2246	0.2841	0.2841	0.3810	0.3810	0.4543
Calculated U.F.	0.210	0.259	0.265	0.339	0.349	0.411
Measured U.F.	0.351	0.300	0.304	0.378	0.380	0.438
Diff. in per cent***	16.3	13.6	12.8	10.3	8.1	6.1

*Fraction of output directly incident on ceiling. Based on special zonal multipliers for 5-degree zones and smaller, derived graphically as explained in Appendix.
**Specially calculated "f" factors for surface reflectances and exact room dimensions.
***Difference between measured and calculated factors in per cent of the former.

bright ceiling, with peripheral elements reflecting as many lumens each as those more centrally located. In this case, more of these lumens are intercepted by walls, and therefore, less reach the work-plane. Conversely, pools of higher ceiling brightness somewhat removed from the walls will result in higher measured utilization factors.

On the other hand, the calculated contribution of the wall may be greater than it should be, for the method assumes that lumens initially incident upon the walls are uniformly distributed, rather than concentrated near the top of the walls, as in the actual case. Light reflected from this area high on the wall will not be as well utilized as that from uniformly bright walls.

In this connection, it is interesting to note that a number of supplementary tests were made with walls having a 12-inch wide zone of 0.80 reflectance at the top; the lower wall was of 0.50 reflectance. This type of reflectance pattern is frequently used, and many lumens strike this white area directly. As compared with a wall uniformly of 0.50 reflectance, gains in utilization factor up to 10 per cent were realized.

Supplementary tests were also made to investigate the ceiling obstruction and light trapping effect of luminaires at different suspension distances. Results for two room ratio values are shown in Fig. 11.

For convenience in predicting illumination results for silvered bowl installations, utilization factors for a range of reflectance combinations and room ratios are presented in Table VI.

Conclusions

Test results indicate that the Harrison-Anderson coefficients, which have, for the most part, served well in practice, are conservative in rooms of higher ratios, but excellent for their test conditions in tall, narrow rooms. Imperfect cosine correction admittedly introduced some differences. Moreover, suspension, location of units, and output distribution may affect comparisons. But as a system it was not intended to apply directly to extremely narrow downward components, and the index thereto and extrapolations based upon it were thus limited. This limitation produced substantial differences. A new flux ratio as an index descriptive

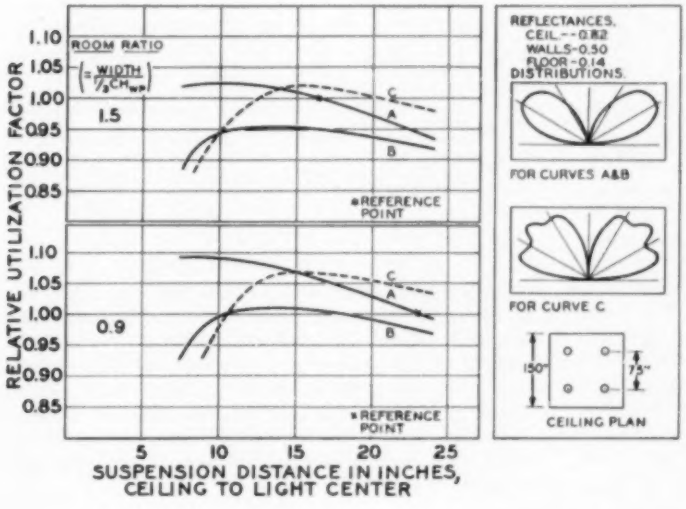

Figure 11. Examples of the effect of varying suspension distance for fixed spacing of indirect luminaires. Curve A applies for the 14-inch diameter open concentric-ring louver unit (black finish inside blades). Note that its utilization is highest at about 10 inches from the ceiling. Curve B shows the lower values resulting when the bottom of the same unit is closed with black cloth; diameter and candlepower distribution are the same. Curve C, for a 20-inch diameter metal unit, shows the effect of a somewhat more concentrated upward distribution combined with additional trapping at short suspensions.

TABLE VI.—Utilization Factors for Indirect Components.*

(Wide Distribution Silvered Bowl Luminaire, See Fig. 10.)

Ceiling Refl.		.80			.70			.50			.30			.10		
Wall Refl.		.50	.30	.10	.50	.30	.10	.50	.30	.10	.50	.30	.10	.50	.30	.10
Room Ratio**																
0.6	(J)	.199	.146	.093	.171	.126	.081	.114	.086	.058	.075	.056	.037	.037	.025	.011
0.8	(I)	.265	.207	.149	.232	.182	.132	.166	.133	.099	.108	.082	.057	.049	.034	.019
1.0	(H)	.325	.262	.201	.286	.231	.178	.207	.170	.132	.132	.104	.077	.059	.043	.026
1.25	(G)	.384	.320	.257	.338	.282	.227	.246	.206	.166	.156	.127	.098	.068	.051	.034
1.5	(F)	.433	.368	.306	.380	.324	.269	.277	.236	.195	.176	.147	.116	.077	.059	.042
2.0	(E)	.514	.448	.384	.451	.394	.337	.329	.286	.244	.208	.177	.145	.090	.072	.054
Floor Refl. .10																
0.6	(J)	.209	.151	.094	.179	.130	.082	.118	.089	.059	.077	.057	.037	.038	.025	.011
0.8	(I)	.278	.214	.151	.243	.188	.134	.173	.137	.101	.111	.084	.058	.050	.034	.019
1.0	(H)	.340	.271	.203	.298	.239	.180	.215	.174	.134	.135	.106	.078	.060	.043	.026
1.25	(G)	.403	.332	.260	.354	.292	.229	.255	.212	.168	.159	.129	.099	.069	.051	.034
1.5	(F)	.456	.383	.309	.400	.336	.272	.288	.243	.197	.180	.149	.117	.078	.059	.042
2.0	(E)	.547	.468	.388	.479	.410	.341	.342	.295	.247	.213	.180	.146	.091	.072	.054
Floor Refl. .30																

*Flux Distribution of unit by 10° zones: (Fraction of Total Output)

90° - 100°,	0.023	120° - 130°,	0.207	150° - 160°,	0.054
100° - 110°,	0.196	130° - 140°,	0.168	160° - 170°,	0.017
110° - 120°,	0.220	140° - 150°,	0.113	170° - 180°,	0.002

For spacing-to-suspension ratio 3.05 - 3.25.
Based on measurements at Room Ratios 0.75, 0.90, 1.2, 1.5.

**Room Ratio $= \dfrac{3\ (\text{width} \times \text{length})}{2\ CH_{wp}\ (\text{width} + \text{length})}$, where CH_{wp} = ceiling to work-plane distance.

of concentration over a wider range appears to have possibilities.

For direct lighting, especially with narrower distributions, the major portion of the light from luminaires is incident directly on the work plane; factors based on zonal-multipliers and interflectance data, in most instances, are close to test results. Where they differ, it is believed that the relative concentration of light directly incident on the walls just above the work-plane is a factor.

As for indirect lighting, we have tabulated measured utilization factors for a wide variety of reflectance patterns and have explored the effects of suspension distance of units. Tests with actual luminaires result in utilization factors which are higher than calculated values despite some obstruction of the ceiling. Differences tend to decrease as room ratio becomes larger. It is believed that the actual variation in ceiling brightness between peripheral and more central elements of ceiling surface is a factor contributing to these differences.

The authors acknowledge gratefully the counsel and assistance of their colleagues, Messrs. Phelps Meaker and Donald West.

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12. FOOTNOTE: In text and graphs of this paper, utilization factor is the ratio of flux delivered (to the reference- or work-plane) to that emitted by the complete luminaire. Efficiency of the luminaire is not involved. To obtain coefficient of utilization, multiply utilization factor by efficiency.
13. FOOTNOTE: Fraction of 0°-90° lumens found in the 0°-40° zone, when there is no 90° candlepower. See also Reference 3.
14. FOOTNOTE: A general equation of a form devised by Russell is shown in the Appendix.
15. FOOTNOTE: Shielding angle is the angle from horizontal throughout which the bulb is concealed.
16. Weits, C. E., and Amick, C. L.: "Luminaire Utilization as Affected by Candlepower Distribution," ILLUMINATING ENGINEERING, Vol. XLIII, p. 65 (1948).
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19. FOOTNOTE: Room Ratio for indirect lighting in this paper is based on the Harrison-Anderson equation: Room Ratio $= \dfrac{\text{width}}{1^1/_2 CH_{wp}}$ for square rooms (recognizing its harmonic mean form for rectangular rooms). The use of two equations (direct, indirect) introduces needless confusion. For example, a room with luminous ceiling would carry a room ratio (direct) different than would apply to an indirectly-lighted room of the same proportions and flux distribution. Potter has proposed to the I.E.S. Committee on Lighting Design Practice a single equation involving width, length and the distance from work-plane to light source, regardless of whether the latter is a primary source (luminaire) or secondary source (reflecting ceiling).
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APPENDIX

Notes on Zonal Multipliers

For accurate comparisons, we have calculated zonal multipliers for zones no wider than 5 degrees, and sometimes smaller depending on the particular situation. Two different methods have been used. One involved estimating the portion of the arc, at the center of each zone, which is intercepted by the walls for each luminaire location. Another employed a general equation and summation process, shown below, which includes all the possibilities of zonal intercepts on walls.

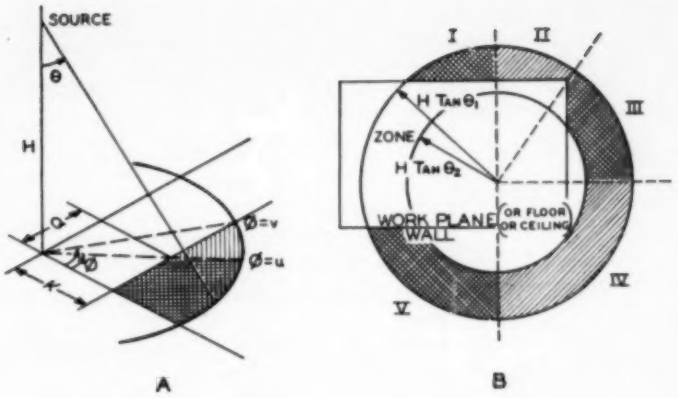

Figure 12. Illustrating solid angles intercepted by walls.

General Equation:

$$\omega = \left[\text{Arc sin} \left(\frac{H \sin \phi}{\sqrt{K^2 + H^2}} \right) - \phi \cos \theta \right] \quad \begin{matrix} \phi = u, v \\ \phi = 0 \end{matrix}$$

See Figure 12A.

Where: ω = solid angle subtended at source by shaded area. (wall intercept)

$$u = \text{Arc sin} \left(\frac{Q}{\sqrt{K^2 + Q^2}} \right) \quad \text{for dark shaded area}$$

$$v = \text{Arc cos} \left(\frac{K}{H \tan \theta} \right) \quad \text{for entire shaded area}$$

By selecting the proper limits, one can determine the solid angle subtended at a single point source by differently shaped segments of any selected zone illustrated in Figure 12B.

Segment	Limits for General Equation*	
	Upper	Lower
I	v	0
II	u	0
III	u	v
IV	$\pi/2$	$\pi/2$
V	v	v

*When evaluating general equation with upper limit use θ_1 to the outer extremity of the zone selected; with lower limit use θ_2 to the inner extremity.

A zonal multiplier for the walls is then determined by adding the solid angles for all wall-intercepted segments of the zone, and dividing by the zonal constant,

$$2\pi (\cos \theta_2 - \cos \theta_1).$$

Zonal multipliers for a complete system of units can be obtained from a weighted average of zonal multipliers for different locations of units. Multipliers for ceiling, work-plane, and floor level are, of course, derived from the proper wall multipliers by subtracting each from unity.

DISCUSSION

BENJAMIN S. BENSON, JR.*: I am very happy to see that the authors are getting along in their monumental task and that it is shaping up as well as it has. Certainly there have been some "bugs" in their preliminary work, but these are being ironed out as evidenced by such refinements as the rotation of certain luminaires and the investigation of luminaire placement in the test area.

*Benjamin Electric Mfg. Co., Inc., Des Plaines, Illinois.

It would be of great interest to further investigate the tying-in of calculations to actual data by means of the relatively simple flux-ratio method. Many of us have felt for some time that the 0°-40°/0°-90° basis could be investigated and the line of attack set forth in the authors' paper should be followed through.

Keeping calculations simple and readily understood is of great importance to this Society. Unlike the electrical and chemical societies, the great majority of membership in our organization is definitely non-technical. I see the trend on one hand for greater accuracy (which we have long been needing) and on the other hand I see the trend for greater simplicity (even at the expense of accuracy). Evidence of this last is in the many short-cut tables of calculations and "one-line" footcandle guides.

In order for any method of prediction to gain full acceptance in this Society, it must be simple — simple to use and simple to calculate. Because of this, any method, be it lumen, interflectance, or what — should be well thought out and reduced to the minimum of equations and "*k*,'s." I am hoping the results of the authors' work can be put into such form.

J. ROY JONES*: I have found the data presented by the authors to be most interesting and helpful. The illumination tests reported on were made to determine the degree of accuracy of calculatd coefficients of utilization. The data show that the Harrison-Anderson coefficients are quite accurate for the conditions for which they were designed. The Zonal Interflectance Method coefficients appear to be more accurate generally, especially for narrow distribution direct luminaires. However, the tests indicate that some further study is desirable.

It is obvious that greater accuracy can be obtained if, in calculating coefficients, the calculations are based on the exact conditions in the room where the measurements are made. Table II, especially, demonstrates the improved accuracy that may be obtained by calculating zonal multipliers for smaller zones and for the exact number of luminaires installed in the test room. In working up a method for calculating coefficients, it is not possible to anticipate the exact number of luminaires that will be installed in an area, but it is possible to provide zonal multipliers for any size zone. The Zonal Interflectance Method is prepared for 10-degree zones; Mr. Potter and Mr. Russell used 5-degree zones in Tables II, IV and V. That makes it possible to get more accuracy, but involves more work in calculating

*Westinghouse Electric Corp., Bloomfield, N. J.

coefficients. On the other hand, the authors suggest a flux ratio system to reduce the amount of work required. *But this also reduces the accuracy.* A compromise between simplicity and accuracy must be made. The use of zones smaller than 10 degrees does not appear practical. An improved flux ratio as suggested by the authors appears to have considerable merit and cannot be dismissed until every effort has been made to work out a satisfactory solution. The formula suggested in the caption to Fig. 8 worked well for the distributions illustrated in the figure, but was less satisfactory for some distributions checked by the writer.

It appears that measured data may be used to adjust the calculations obtain more accuracy (particularly for indirect luminaires), and at the same time perhaps it will be possible to effect some simplification. A flux ratio for the upward distribution appears to be more practical than one for the downward distribution.

Table I is of particular interest. The table indicates that the shape of space below the work plane (height of work plane above floor) is not particularly important. It is interesting to note that this space is not included in calculating the room ratio using the conventional I.E.S. formulas, but is included in the computation of k_r. In the example illustrated by this table, k_r was changed from 0.53 to 0.43 by raising the floor from 30 inches below the work plane to 15 inches below the work plane. If k_r were the true and proper means of classifying rooms according to shape, this should have raised the measured utilization approximately 6 per cent instead of only 0.6 per cent as was the actual average. This tends to prove that the I.E.S. treatment of room shape is more accurate than the concept of k_r, and that k_r and room ratio are different entities, as pointed out by Mr. Potter previously.[1]

1. Potter, W. M.: "Memorandum on Room Ratio for the Lumen Method of Lighting Design," unpublished.

DOMINA EBERLE SPENCER*: The authors are to be congratulated on a very careful and valuable piece of experimental work. The comparisons with values calculated from the interflection method turn out much as would be expected. Errors of the order of 10 per cent are sometimes obtained. In high, narrow rooms the results are more sensitive to the exact arrangement of luminaires than in very large rooms.

Figs. 3, 4 and 10 contain data taken from our Franklin Institute paper,[1] which gives values of interflectance for canonical luminaire distributions. In this paper, the light sources were assumed to be continuously distributed rather than separate. Thus, in small rooms somewhat more light was thrown on the walls than would occur with an actual array of individual luminaires. The resulting calculations of interflectance are slightly conservative. This accounts for the difference between the values marked by *X* in the Potter and Russell figures and their experimental data. In Mr. Innis'[2] application of the canonical method, he has compensated for the discrepancy caused by the use of continuous distributions, and he obtains excellent agreement with the experimental data.

In employing the interflection method or the lumen method — in employing any method based on a single room index — we should realize that there are inherent limitations to the accuracy of the calculations. We are accustomed to say that the effect of room shape is taken care of by the *domance* or room index. It is often said the Hisano[3] proved this experimentally. Certainly the integral equations on which the interflection method is based[4] contain no function of room shape except k_r. But is this specification of room shape an exact law of photometrics? Or is it merely a satisfactory approximation in a wide variety of cases?

Consider a room with a perfectly diffusing luminous ceiling and black walls and floor. From the *basic interflection equations*[5] the interflectance of this room is

$$f_2 = e^{-2k_r(h'/h)} \qquad (1)$$

where $k_r = \dfrac{\text{Wall area}}{4 \text{ Floor area}}$,

h' = distance from ceiling to principal surface,

h = ceiling height.

This is an approximate equation obtained by use of exponential kernels.

Exact equations for f_2 in a black room can be derived for specific room shapes.

In a *circular room*,[6]

$$f_2 = (1 + 2k_r^2 (h'/h)^2)\left[1 - \sqrt{1 - \left(\frac{1}{1 + 2k_r^2 (h'/h)^2}\right)}\right] \qquad (2)$$

In a *square room*,[6]

$$f_2 = \frac{8}{\pi}\left[\Phi(\gamma_1) - \Phi(\gamma)\right]. \qquad (3)$$

where $$\tan \gamma_1 = \frac{1}{\sqrt{1 + (k_r (h'/h))^2}}$$

$$\tan \gamma = \frac{1}{k_r (h'/h)}.$$

$\Phi(\theta) = \frac{1}{2}\left[\theta \cot \theta - \frac{1}{2} \log \sin \theta + \frac{1}{2} \cot^2 \theta \log \cos \theta\right]$.

In a *very long rectangular room*,

$$f_2 = \sqrt{1 + (2k_r h'/h)^2} - 2k_r (h'/h). \qquad (4)$$

All of these equations give the interflectance as a function of k_r and the position chosen for the principal surface. They are *four different functions.*

Table D-I and Fig. D-1 (of this discussion) show the

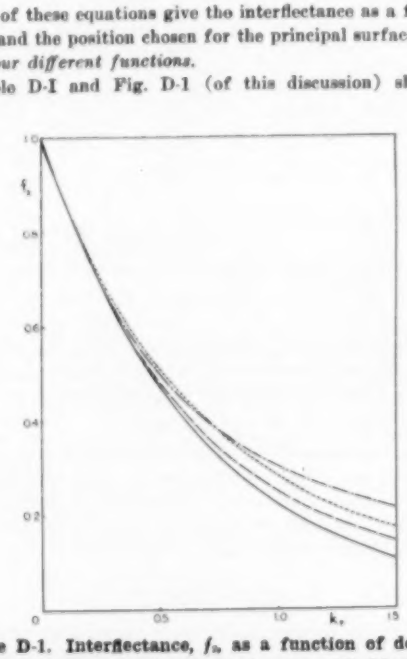

Figure D-1. Interflectance, f_2, as a function of domance, k_r, for a luminous-ceiling lighted room with black walls and floor. Principal surface is at ¼ ceiling height.

Exponential Approximation, Eq. (1) ————————

Exact Expressions

Circular Room, Eq. (2) —— —— —— ——

Square Room, Eq. (3) — — — — — —

Very long rectangular room, Eq. (4) —— — —— — —— —

*University of Connecticut, Storrs, Conn.

TABLE D-I.—Interflectance for Black Rooms with Ceiling Lighting. ($h'/h = 0.75$).

	Interflectance f_2 — Exact Expression			
k_r	Exponential Approximation Eq. (1)	Circular Room Eq. (2)	Square Room Eq. (3)	Very Long Rectangular Room Eq. (4)
0	1.000	1.000	1.000	1.000
0.1	0.861	0.863	0.863	0.861
0.2	0.741	0.742	0.755	0.744
0.3	0.638	0.640	0.660	0.647
0.4	0.549	0.554	0.580	0.566
0.5	0.472	0.480	0.510	0.500
0.6	0.407	0.418	0.450	0.445
0.7	0.350	0.365	0.399	0.400
0.8	0.301	0.321	0.355	0.362
0.9	0.259	0.282	0.309	0.330
1.0	0.223	0.250	0.283	0.303
1.5	0.1054	0.1444	0.170	0.212
2.0	0.0498	0.0919	0.111	0.162

results of calculating f_2 as a function of k_r. The principal surface was assumed to be at one-quarter of the distance above the floor, so $h'/h = \frac{3}{4}$. Calculations were made on a computing machine to five figures and subsequently rounded to three figures. It will be noted that all four equations agree at small values of k_r. But as k_r increases, discrepancies become increasingly evident. Even the two curves, from Eqs. (3) and (4), for different types of rectangular rooms are different; in fact, they cross at $k_r = 0.65$. It is only by introducing the exponential approximations employed in the interflection method that it is possible to describe room shape by a single constant k_r.

Two lessons can be learned from this analysis:

(1) The use of k_r to specify room shape is *not an exact procedure: It is merely an approximation.*

(2) Calculations by *any lumen method* are inherently inaccurate at high values of k_r.

Consequently, lengthy arguments on the exact procedures for employing any lumen method in small rooms ($k_r \cong 1$) are of questionable value. We cannot hope for calculations accurate to half a per cent. It is fortunate that the method is sufficiently accurate for most practical problems.

The exponential approximation gives results that are conservative for cubical rooms. Perhaps this is an advantage, for it is in just such rooms that the introduction of furniture will have the greatest effect.

The interflection method was not designed for the lighting of black broom closets by luminous ceilings. In such cases it may be conservative by about 50 per cent. For good lighting designs, however, the interflection method will ordinarily give results accurate to 10 per cent. In general, the better the quality of the lighting system, the more accurate will be the results.

So much of the Potter and Russell paper is excellent that I should perhaps refrain from making any criticisms whatever. However, it is tempting to ask some questions:

(1) Is it not a bit old-fashioned to confine a modern paper to the floor reflectance and luminaires of 1915?

(2) Is it wise to call *interflectance* "utilization factor"? Isn't this far too easily confused with coefficient of utilization?

(3) Would not the whole paper be greatly simplified if room shape were expressed in terms of the *domance* k_r, if letter indices were abandoned, and if mounting height were treated as an independent factor?

1. Moon, Parry, and Spencer, D. E.: "Interflectance Calculations for Various Luminaires," *J. Franklin Institute*, 252 (1951).
2. Innis, L. E.: "Interflectance Tables from Conventional Photometric Data," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 11, p. 595 (November 1953).
3. Hisano, K.: "Light flux distribution in a rectangular parallelepiped and its simplifying scale," *Researches Electrot. Lab.*, Tokyo, No. 394, (1936) (In Japanese); English translation by H. Shiramizu, ILLUMINATING ENGINEERING, Vol. XLI, p. 232 (1946).
4. Moon, Parry, and Spencer, D. E.: "Light distributions in rooms," *J. Franklin Institute*, 242, p. 11 (1946).
5. Moon, Parry, and Spencer, D. E.: *Lighting Design*, Addison-Wesley Press, Cambridge, Mass., Appendix D.
6. Moon, Parry: *Scientific Basis of Illuminating Engineering*, McGraw-Hill Book Co., p. 338 (1936).

W. M. POTTER and A. H. RUSSELL*: The authors wish to thank the several discussors of this paper for their kind and constructive comments.

Mr. Benson emphasizes two trends in utilization data — first, that calling for greater accuracy, and second, that toward greater simplicity. Mr. Jones suggests that a compromise between accuracy and simplicity must be made. The authors believe that it is desirable to have available comprehensive basic data of a high order of accuracy. Then such data can be abridged or simplified as required and presented in forms readily employed.

As indicated, we have provided basic data by careful measurement and have compared some of the results with calculated values. Some are compared with published calculation data as accurate for the conditions as available, Figs. 3, 4, 6, and 10. But, to insure fair evaluation of a calculation *method*, it seemed obligatory to assume for calculation purposes exactly the same conditions, including numbers of units, as employed in the test rooms. To this end also we used smaller zones than Messrs. Jones and Neidhard selected for their published tables, but 5 degrees or even smaller zones[1] are permissible in a zonal-interflection system. Mr. Jones points out their greater accuracy. The authors were happy to expend the extra effort necessary for a sound comparison.

Of course, this does not imply that general utilization data must be available for every possible pattern of luminaires. However, the authors believe that data for a wide range of patterns — from only a few luminaires to an extensive array of contiguous elements—should be available to meet present-day needs.

The flux-ratio concept was discussed as a possible means of simplifying construction of coefficient-of-utilization tables. It is a means of presenting or extending basic data from any source, calculated or experimental. Other advantages of this concept are discussed in the text. The type of flux ratio suggested by Meaker (see Caption, Fig. 8) gives promise of reasonably accurate determination over the entire range of concentration.

Since the preprinting of our paper last summer, zonal multiplier-interflectance calculations of utilization factor have been made for the representative distributions used in Fig. 8 and for 28 others for an 0.80, 0.50, and 0.30 reflectance pattern for ceiling, walls, and floor respectively. The plot of Fig. 13 (Rebuttal) here presented, shows that the deviation of these individually calculated values from the curves is within about three per cent.

Dr. Spencer has properly called attention, as we did in presentation, to the assumptions which underlie the data designated by X in some of our charts.[2] These data for certain flux distributions were calculated for test room conditions of $h = 10$ feet and $h'/h = 0.75$. In this reference it is indicated that one seems justified in replacing discrete luminaires by a fictitious continuous distribution, although somewhat lower values result. Naturally, the utilization to be expected from a continuous luminaire coextensive with the room would be lower than that from an array of individually spaced luminaires.[3] Mr. Innis[4] has corrected the

*Authors.

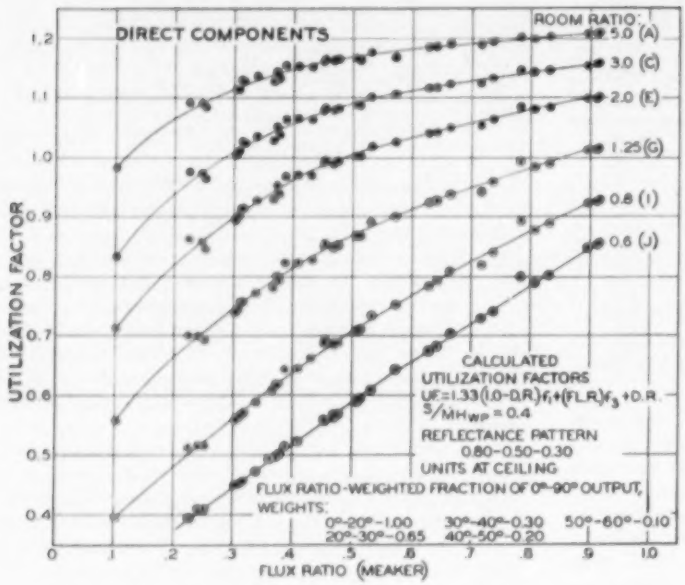

Figure 13 (Rebuttal).

direct ratios (a_w) upward for separate luminaires of cosine distribution, although the basis for the revision is not given. We find that his tables show only slightly higher results than the above mentioned values — a substantial difference remains. Coradeschi and Innis'[5] value, based on experiment, for some system of discrete industrial luminaires is even lower than the calculated value for the continuous ceiling.

For most curves the 14 per cent floor was selected to facilitate comparisons with other published data. As indicated in our text, our tests have included floor reflectances as high as 40 per cent. Some of the data resulting therefrom are shown in Table VI for floor reflectances of 10 and 30 per cent, values selected by the Lighting Design Practice Committee as typical and desirable for published tables.

Of course, the luminaires themselves are merely a means of producing a desired flux distribution. Some of these, such as the R-52 and narrower distributions, are relatively recent. One, the RLM, is typical of 1915-1920 as well as later periods, and was selected for comparison; moreover, its distribution is approximately that of an element of a diffusing transilluminated panel or ceiling.

We are aware that there has been confusion in the nomenclature of utilization. Harrison and Anderson used the term "coefficient of utilization" to designate two ratios: (1) light delivered (to the work- or reference-plane) to light generated by the primary sources (lamps), and (2) light delivered to light emitted by the luminaire. "Coefficient of utilization" has been generally adopted for the first of these fractions, although sometimes "factor" and "coefficient" were used synonymously. The second ratio or fraction is more basic, because it is a function of the relative flux distribution (shape of candlepower curve) and not of efficiency. Hence, when its value is determined for one type of distribution, multiplication by efficiency easily provides coefficients for all luminaires having that distribution. In many publications written over a considerable period this second fraction has been designated as "utilization factor."[3, 6, 7, 8] (See also Footnote 12.) Hence the question, "Is it wise to call interflectance 'utilization factor'?" might be reversed. The term "interflectance" has been proposed as a name for this second fraction, but it is used in interflection literature to designate another quantity also: the fraction of flux incident on (or emitted by) a room surface, which reaches the work-plane directly or by reflection. When employed in the sense of "utilization factor" of a luminaire system, it may be the weighted sum of two or three such fractions plus a term (often of substantial size) representing light which does not undergo reflection at all.

No doubt the appropriate Committees should define carefully the quantity in question and possibly consider an entirely new name for it, such as "utilance."

It does not appear that the use of $k_r = \dfrac{h\,(w+l)}{2wl}$ as an expression for room proportions (with the additional factors for position of reference-plane and mounting height of luminaires), would effect a simplification in this paper. This expression seems well suited for dealing with light which is inter-reflected between boundary surfaces of the room. However, the authors feel that the most suitable measure of proportion for utilization purposes would be a single equation such as outlined in Footnote 19, since in most cases the major portion of the utilized flux reaches the work- or reference-plane *directly* from luminaires or from ceiling surfaces. This proposal involves the distance from light source to work- or reference-plane, regardless of whether the source is primary (luminaire) or secondary (reflecting or transilluminated ceiling).

1. Footnote: We have not advocated these smaller zones for general use.
2. Moon, Parry, and Spencer, D. E.: "Interflectance Calculations for Various Luminaires," *J. Franklin Inst.*, 252, p. 11 (1951).
3. Potter, W. M., and Oetting, R. L.: "Design and Illumination Characteristics of Louver and Louverall Systems," ILLUMINATING ENGINEERING, Vol. XLIV, pp. 16 and 341 (1949).
4. Innis, L. E.: "Interflectance Tables from Conventional Photometric Data," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 11, p. 595 (November 1953).
5. Coradeschi, R. A., and Innis, L. E.: "An Application of the Interflection Theory to Commercial Practice," ILLUMINATING ENGINEERING, Vol. XLIII, p. 949 (1948).
6. Potter, W. M., and Meaker, Phelps: "Luminous Architectural Elements," *Transactions of the Illuminating Engineering Society*, Vol. XXVI, p. 1025 (1931).
7. Krachenbuehl, J. O.: *Electrical Illumination*, John Wiley and Sons, Inc., New York, 1942.
8. Krachenbuehl, J. O.: see discussion of paper by C. E. Weitz and C. L. Amick, "Luminaire Utilization as Affected by Candlepower Distribution," ILLUMINATING ENGINEERING, Vol. XLIII, p. 65 (1948).

Design for Simplified Hangar Illumination

By RICHARD D. PRESCOTT

IN THE course of a designer's career in this often pioneering field of illumination, some designs spark gratification above all others. The cold cathode interior illumination designed by the writer and installed in the new T.W.A. Hangars at Midway Airport, Chicago, is such a design. This work was done in collaboration with the late Chauncey L. Chase, Mechanical Engineer, under sub-contract from the firm of Ammann and Whitney, who were the prime consulting engineers.

The accompanying photograph shows the continuous rows of ceiling lights arranged transversely beneath the ribbed arch roof. The rows are spaced 12 feet on centers and consist of individual fixtures 8 feet in length combined to form continuous lengths of 24 and 56 feet. Details of the luminaire designed for this installation may be noted in Fig. 2. As noted by the simplicity of design the manufacturing of these fixtures was not necessarily limited to any special firm. Each individual eight-foot unit contains four lamps mounted in sockets with safety guards and is equipped with reflector wings, as shown. The lamps are 3500° white, 25 mm dia., 7 feet 9 inches long, 2300 lumens at 100 hour burning. Transformers are of the constant voltage type, 115/825 volts and 120 ma. A summary of light meter readings taken by the T.W.A. field engineer 14 months after installation is set forth in Fig. 3.

Other controlling factors in the selection of this type of lighting were the high resistance of cold cathode lamps to severe temperature and atmospheric changes — as well as the fact that they start instantly without flicker, and are unaffected by vibration. The first three rows at the arch extremities each consist of two 24-foot lengths, with 6-foot space between adjacent ends. In these end groups the luminaires are mounted flush with underside of structural ribs so as to maintain ample clearance, thus affording unobstructed passage for plane wings and avoiding the likelihood of injury to fixtures. The rows of fixtures in the main arch be-

PERTINENT DATA ON T.W.A. HANGAR

Twin hangar — reinforced concrete arch construction.

Span = 270 feet; minimum clearance 18 feet 0 inches at buttresses.

Depth = 125 feet.

Height approximately 65 feet at crown.

Rib spacing 30 feet 10 inches.

Thin shell between ribs, 3½ inches thick haunched to 5½ inches at ribs and edge beams.

Hangar doors — 40-foot clearance with provisions for future 15 feet for high tail door.

Radiant heating to keep tracks free of snow and ice.

AUTHOR: Consulting Engineer, New York, N. Y.

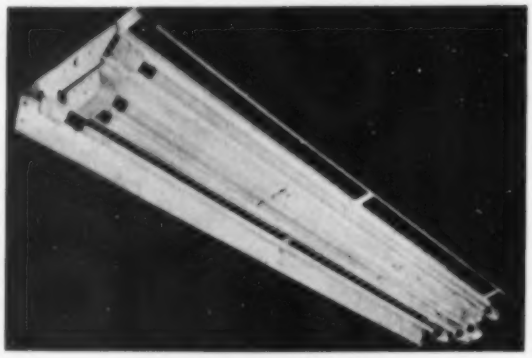

Figure 2. Luminaire design.

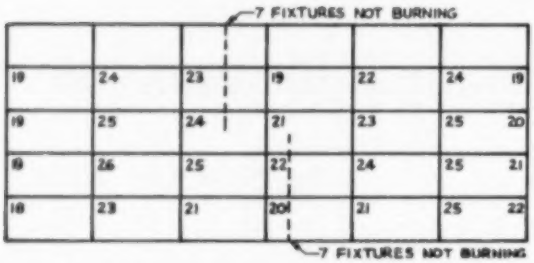

Figure 3. Footcandle readings taken at night with all lights on except as noted, and on 25 x 50-foot spacings.

tween extremities each consist of 56-foot continuous lengths and are suspended to elevations below the structural roof members as required to achieve the lighting pattern and design intensity at working plane. The luminaire mounting heights vary from approximately 22 feet above the floor at the arch extremities to 62 feet at the center of the hangar. Fixtures are permanently secured in position, as mechanical appurtenances for lowering were not desired.

In addition to satisfying the normal dictates of utility, economy and simplicity, the installation features efficient, adequate and uniform level of ilumination, compactness in design and flexibility in selective control of lights.

Uniform lighting was achieved by employing four-tube, winged, reflector type fixtures having all white, porcelain enameled finish. These units were specially designed so that all the light output from the two center tubes and 85 per cent of the output from the two wing tubes would be directly downward and 15 per cent of the output from the two wing tubes would be dispersed upward to the white ceiling, for downward reflection to the working plane.

The unobstructed span of light produces, in effect, a luminous ceiling, beneath which servicing of T.W.A.'s giant Constellations and Stratocruisers can be accomplished with speed and efficiency. Lighting levels at the various servicing areas are lower than I.E.S. standards as given in the *Handbook*, but are maintained at fully 50 per cent higher than average requirements specified by T.W.A. The client no doubt had an eye focused on the watt hour meter mentally multiplied by a possible factor of twenty-four. For the statistically minded the total light output (measured in lumens) for each hangar is 2,960,000 — or translated into watts approximately 60,000.

Well planned, simple circuits, combined with proper grouping of fixtures according to service demands, made possible a very compact panel arrangement at each end of the hangar, thus consuming a minimum of wall space.

Controlwise, the ceiling lights are zoned into quarters. This zoning permits selective groupings of rows as well as control of individual rows within each quarter.

As previously stated, the fixtures are permanently secured in position and no mechanical means for lowering are provided. While this decision was taken primarily in the interest of economy to recover the investment for a portable elevated staging required for maintenance of the blow-down heaters and other mechanical equipment located at the apex of the hangar, many other benefits resulted. The possibility of interruptions and delays in cleaning operations, which often occur because of operational failure in mechanical suspension apparatus, was eliminated. In addition, by maintaining the ceiling free of appurtenances the design was materially simplified, interferences avoided and the incessant clamor for cleanliness was automatically satisfied as there are no extra paraphernalia to collect and hold dust. The design proper was as stated enhanced by the simple expedient of utilizing the compulsory maintenance equipment which would otherwise remain substantially idle throughout its corrosive march to the junk heap. This is not to imply that mechanical suspension apparatus is not desirable, for this would be incorrect. In certain applications they are a must, as every experienced designer is well aware. However, in circumstances similar to the design under discussion, the benefits resulting from the omission of mechanical suspension apparatus, as set forth above, are quite attractive.

We are told that the most real progress is extracted from the lessons of past design. The basic features of the T.W.A. Hangar design have been presented here in full confidence of their potential impact on The Modern Trend in Hangar Illumination.

Lighting Progress in 1952-1953

Prepared by the Committee on Progress of the Illuminating Engineering Society

THE 1952 Progress Report chronicled the first production of useful electric power from converted atomic energy. The now historical experiment of December 20, 1951, set in motion a whole new realm of speculation about commercial electric power production. Lighting was closely tied to this new science milestone because familiar 100-watt incandescent lamps consumed the first power released in the demonstration.

As we approach the second anniversary of the Atomic Energy Commission announcement, we can hear more definite predictions about the nearness of practical sources of atomic power for generation of electricity. Now we hear of the first full-scale power reactor for industrial use with a minimum of 60,000 kilowatts, to be finished in about three years, constructed by partnership of government and private industry.

The Diamond Jubilee of Light in 1954 will fittingly celebrate the invention of the first practical electric incandescent lamp and we all recall that it was the *lamp* that actually brought the electric *power* industry into being, since power and its transmission was necessary to make the lamp operative.

Hence it is a coincidence that we may look forward to 1956, the Golden Anniversary of the I.E.S., when it is not unreasonable to expect that we shall be able to report about another dramatic birth of an industry of power — atomic power — to light our lamps and do our work!

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*assisted by J. A. Bartelt

Light Sources and Circuits

Progress in light sources for this year has given us new variations in filament types and special purpose lamps and a number of advances in vapor lamp development.

Filament Lamps

The general trend continues toward reduction in bulb sizes particularly among household lamps. With it the consumer can get more light from existing luminaires, some of which restrict the size of lamp bulb that can be used. The latest of the group is the 200-watt PS-30 which is now available in the PS-25 bulb.

The high efficiency inside white fumed silica coated lamps have a new family member, the three-light form, 50-100-150-watts in one bulb, to give a degree of greater diffusion over the inside-frosted lamps.

Small flashlight and hand lantern bulbs are appearing in special forms for new applications. One type, the PR-14, has two filaments, spot and flood, in the same bulb, operated by a three-position switch on the flashlight housing; thus, a dual purpose unit is achieved in a single housing. The first prefocus hand lantern lamp, the PR-13, is designed for 4.75 volts and 0.5 amperes and delivers a compact light pattern under good optical control.

A variation of mechanical base R-40 reflector bulb construction, with shortened glass seal, results in the same overall length as standard based lamps using high temperature basing cement. Such lamps are announced in 100-, 150- and 200-watt sizes.

The R-47 temperature-shock resisting glass gold reflector infrared lamp, reported previously, reached full-scale commercial form this year and appears as a surface cooking unit in an electric range. The unit, shown in Fig. 1, consists of a 1550-watt temperature-shock resisting lamp mounted in a metal reflector shell and covered by a red, heat treated temperature-shock resisting glass cover set in a flush surface ring on the stove.

Coiled-coil filaments are now used in railway headlighting lamps and airplane landing lights to provide improved beam shape and higher efficiency.

Several new projector bulb types of aviation lamps have been announced:

1. 250-watt 28-volt PAR-46 landing lamp with maximum light output for emergency jet plane landings where peak candlepower at minimum load is helpful. The lamps are designed for 10-hour life.
2. 450-watt 28-volt PAR-46 10-hour lamp for use where higher wattage is practical.
3. 250-watt 26-volt PAR-56 spot and flood lamps for cargo loading and sea rescue service.
4. 399-watt 115-volt PAR-56 lamp for slopeline airport approach lighting systems.
5. 75-watt 28-volt PAR-36 airplane passing light.
6. 50-watt 6.5-volt PAR-36 carrier deck landing lamp. The beam has a sharp top cut-off to prevent upward glare.

Some automobile manufacturers have changed to 12-volt electrical equipment. This provides more power in the ignition system of higher compression engines and aids the growing use of power consuming accessories such as electric window lifts, air conditioning machinery, power seats and other devices. This move has necessitated the development of improved 12-volt sealed beam headlamps as well as other 12-volt automobile lamps that more closely approach the performance of 6-volt types. The average automobile in 1953 may be equipped with more than 30 lamps — that is, more lamps than in some homes!

Two pastel tints, Blue-White and Pink, have been added to the basic group of Red, Yellow, Blue and Green 150-watt reflector R40 bulbs to give a technically well chosen range of color

A report presented at the National Technical Conference of the Illuminating Engineering Society, New York, N. Y., September 14-17, 1953. Approved by the Council of I.E.S., February 11, 1954.

Figure 1. Progress Committee Chairman, T. C. Sargent, exhibiting heat lamp cooking unit.

harmony and contrast. The permanently "fired on" color is said to remain true throughout the life of the lamps. The Pink gives a warm, soft light that mixes well with Deluxe Warm Fluorescent and the Blue-White has a cool daylight quality that mixes well with Standard and Deluxe Cool White fluorescent lighting.

There are several new types of photographic lamps. More compact flashtubes are aiding the photographer. The FT118 provides 125 watt-seconds at 40 lpw and the FT218 yields 200 watt-seconds at 50 lpw. The demand for photoflash lamps continues to exceed productive capacity and when one realizes that this now means a consumer appetite of well over a million lamps per day, the significance of this part of the industry becomes plainly evident. Two new blue coated lamps were announced for use with daylight color films: the 6B midget type focal plane lamp, physically the same size as the regular #6, and the 31B which is physically the same as the regular #31, except for the blue coating.

A submidget photoflash lamp, the PH-8, was introduced to provide a smaller flash lamp than the previously available midget but still have a photo-effectiveness equivalent to the midget. Another miniature form of flashlamp was released as a Bantam #8 (Fig. 3). These lamps fit midget sockets and reflector units, have a 3800K color temperature, 7000 lumen-seconds output, 20 microwatt-seconds peak, 3-45 operating voltage and three amperes. "Miniaturization" in flash lamp design seems to be a popular move. When combined with properly designed reflectors, the camera fan has a convenient source of dependable light for adequate exposures without the bulk of larger units.

Basic improvements in optical effectiveness of filament projection lamps were achieved during the year. One company announced a more compact biplane filament high powered lamp for motion picture projection which is said to give up to 20 per cent more screen illumination than previous lamps of equal wattage.

Last year we heard of the vital but tiny airplane instrument lamp. Over 1000 of these may be used on each big bomber, and size and weight of lamps and housings must be minimized. A comparable lamp has been developed for the Navy this year for use as an electric power panel indicator lamp. The T-1¾ bulb with midget screw base answers the need for small size.

Mercury Lamps

Public interest in street lighting has enlarged the mercury lamp market. New 700-watt BT-46 A-H18 mercury and B-H18 fluorescent mercury lamps bridge the gap between previously announced 400- and 1000-watt types. While principally designed for industrial lighting the new units can be useful in high level illumination of wide streets and boulevard areas.

A new "shock proof" mounting of the arc tube in 400-watt R-1 and RC-1 lamps is used by one manufacturer to give more rugged construction.

Photochemical lamps in the 48T6 quartz form are now produced in 2000, 3000 and 4000-watt sizes. These wattages in small diameter tubes, low current and high efficiency designs are applicable in photoprinters and photoreproduction machines, as well as in photochemical processes.

Simplified short-arc lamps in the 800- and 1000-watt sizes have been given extensive military and civilian service tests and are listed as particularly useful for searchlight and projection applications.

Fluorescent Lamps

Stability in fluorescent lamp types is increasingly evident. The 90-watt T17 is generally superseding the 85- and 100-watt sizes in most applications. No definitely new general lighting lamps

Figure 2a. Full-size operating demonstration of new fluorescent and 700-watt mercury street lighting luminaires.

Photos: Bob Blatt, Electrical World

Figure 2b. "Bubble" lamps and Certified lamps were part of the residence lighting demonstration.

have been announced. Color standardization is now accepted by most manufacturers.

Standard Cool White is by far the most widely used, representing almost 50 per cent of total sales. Daylight and White each run about 20 per cent of the total, and Deluxe colors plus all others amount to about 10 per cent of the total. Deluxe Warm and Deluxe Cool are growing in popularity and Daylight and Soft White are receding. New slimline installations in particular show a predominant choice of Cool White, both Standard and Deluxe.

Growing acceptance causes the 96T12 to surpass all other sizes of lamps, based on lumens produced. The demand for instant starting by elimination of starters and the parallel demand for easier maintenance of lighting installations constitutes a real trend. Not only is this evident for instant start slimline types but it also includes the growing popularity of the 40-watt rapid start lamp and circuit as well as the trigger start operation of circline and smaller size fluorescent lamps. Rapid start ballasts are now certified.

Flexibility in current loading of slimline and rapid start lamps is now more practical due to evolution of electrode design. Slimline operation from 120 to 600 milliamperes and rapid start operation up to one ampere is now common practice. Sub-normal loading helps in obtaining lower brightness conditions and above normal loading aids maximum light output.

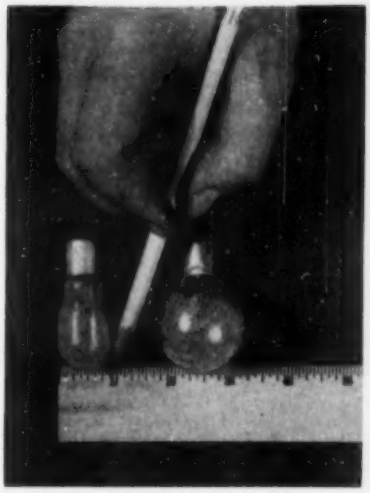


Figure 3. New Bantam 8 and PH-8 are smaller than previous Midget bulbs, yet give 7000 lumen-seconds output.

Flexibility in ballasting is becoming more common. See section on Ballasts following under Luminaires.

A special group of hot cathode slimline lamps has been developed for subway and street railway service. The emissive mixture is fused on to the coiled coil tungsten filament to provide long service on intermittent operation.

One manufacturer reports several special purpose lamps: a golden yellow coated fluorescent lamp for insect control; an improved daylight color with greater output and better color rendition; a turquoise color for use where a cool green color tone is desired; and a photographic lamp with approximately 2600K color temperature for use without filters on certain types of film.

The outdoor use of fluorescent lamps is worth special recognition. While the fluorescent lamp is not fundamentally a low temperature device in concept, consumer demand has gradually forced attention to accessory equipment and circuits that will permit satisfactory outdoor and reasonably low temperature operation. Street lighting is an obvious application and others are gasoline and service station lighting; railroad, bus and air terminal lighting; signboards; loading platforms; outdoor food stands, amusement areas; storage or work yards; parking or service spaces; tunnels and underpasses. Techniques for obtaining dependable lamp starting and acceptable lumen output are now considered practical. The outdoor plastic enclosed sign is one special application for which a growing family of single pin instant start lamps is available. Sizes now used include 24-inch, 30-, 33-, 36-, 42-, 48-, 64-, 72- and 96-inch lengths.

Growth of Lamp Use

A new peak for large lamps was reached in 1952; 950,594,000 incandescent filament and almost 80,000,000 fluorescent lamps were reported. Photolamps passed a peak of 342,000,000 units and the spectacular rise continues. Miniature and automotive lamp use fell off somewhat since 1950; 366,000,000 units were used during 1952.

Figure 4. "Before" and "after" views of a great improvement brought by new industrial lighting. Good shielding with upward light are hallmarks.

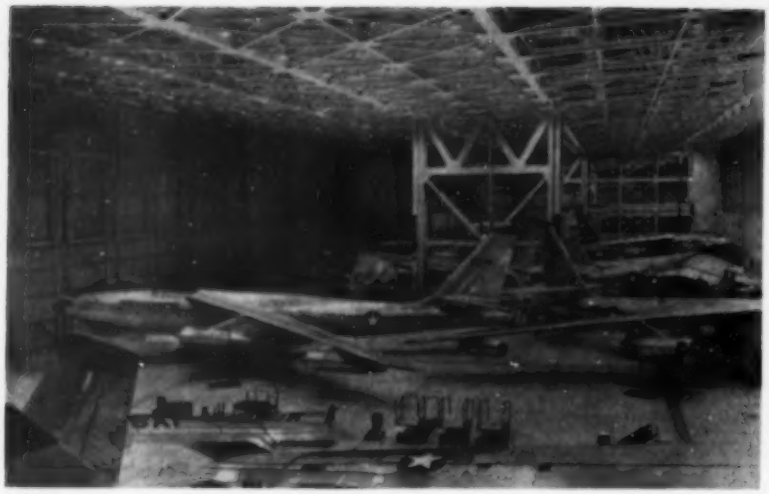


Figure 5. Equal numbers of 1000-watt A-15 mercury and 1000-watt filament lamps provide 50 footcandles in a high bay installation at the Boeing plant at Wichita.

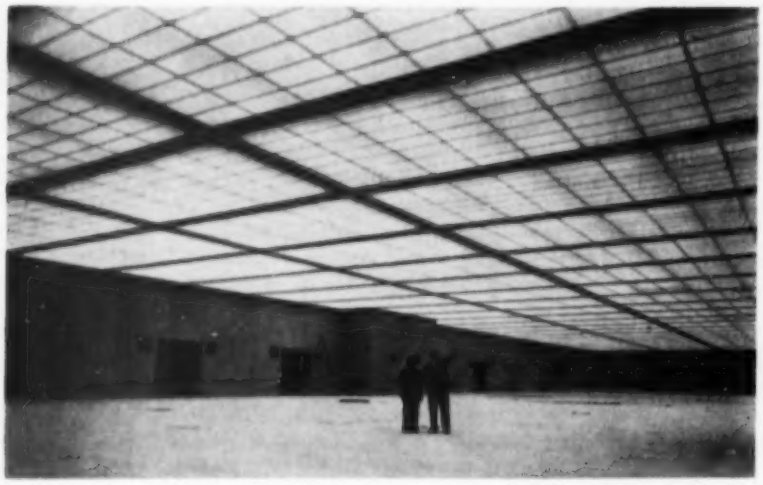


Figure 6. Large area louvered ceiling with acoustical treatment for industrial or commercial spaces.

General Applications

Last year's Progress Report featured the improved designs of industrial luminaires and new R.L.M. specifications which recognize the quality trend in industrial lighting. This year has brought wide acceptance of the new systems and many examples have been shown in commercial publications. Fig. 4 shows "before" and "after" pictures of the assembly line at R.C.A. Estate Stove Co., Hamilton, Ohio. Good shielding and substantial amounts of upward light are hallmarks of the best practice in industrial lighting.

High mounted luminaires using the larger wattage mercury lamps now available help to provide improved visual comfort in large industrial areas. Fig. 5 shows the results obtained from 1000-watt A-15 mercury lamps and 1000-watt filament lamps in an aircraft plant. More than 50 maintained footcandles of illumination are delivered at working levels. Similar results can be obtained by use of color corrected mercury units, both as reflector color improved lamps and as the BT models available in sizes from 400- to 1000-watts.

Fluorescent slimline lamps may be helpful in high bay areas too. One installation is reported in a turbine room at the Kearny, New Jersey station of the Public Service Electric and Gas Company.

Color-critical industrial applications are adopting the Deluxe fluorescent lamps. The past year has brought reports of their use in food-processing, map making, woodworking, textile and color printing plants. Deluxe Cool White grows in acceptance for such critical applications.

Louver type ceiling construction or corrugated plastic ceiling areas or various combinations of louvers, pans, modules or geometric shapes, metal or plastic, give wide opportunity to designers to produce custom effects. Fig. 6 is a large area installation at the Ford Research and Engineering Center. Acoustically treated areas alternate with louver sections. Calculated average maintained illumination ranges from 100 to 115 footcandles at 30 inches above the floor in several parts of the total installation.

Many special equipments for the cleaning of fluorescent luminaires have been reported over the year, but they have usually been designed to satisfy the requirements of one particular installation. One commercial unit has been designed by a group of lighting engineers working on maintenance problems and put to use by a company in the business of maintaining fluorescent lighting. After favorable field experience, the maintenance company has decided to manufacture and market the unit. It contains a heated tank for washing luminaires in a detergent solution, a separate rinse tank, and drain racks, all in a single portable unit.

School Lighting

Close adherence to the principles of good school lighting as set forth in the American Standard Practice for School Lighting continues to be the trend in the relighting and new lighting of schools. Lighting educational programs for school administrators have been so effective that some school administrators say they know more about quality lighting than some of those who call upon them on lighting matters.

The first major installation of rapid-

start fluorescent lamps was made in the Jefferson and Lincoln Schools, Wauwatosa, Wisconsin. Classrooms are lighted with three rows of 45-degree louvered semi-direct luminaires, providing 45 footcandles. The installation is typical of the better school lighting now in general use.

Fig. 7 is an example of the careful attention to good classroom lighting in the schools of Newton, Massachusetts. All-plastic shielded lighting units are standard in all modernization and new construction programs.

The corrugated plastic ceiling technique may be applied to classrooms, too. Fig. 8 is a typical illustration of such an approach in the classrooms of the Central School in Mount Prospect, Illinois.

Construction savings resulting when the cubical content of buildings is reduced have created much interest in low ceiling (9 to 10 feet) classrooms. Fig. 9, from a paper presented at the Great Lakes Regional Conference in Syracuse, shows that two typical rows of luminaires on a 9-foot ceiling classroom will not be satisfactory from a uniformity of illumination standpoint. Three rows are reasonably satisfactory, but conditions would be better if a 10-foot ceiling height were used. Since several states now permit low ceiling construction, designers and manufacturers are giving more careful attention to new luminaire concepts that will specifically serve this special field.

The trend toward lower ceilings reduces the amount of light available through the wall fenestration, and investigations are being made as to the possibilities and feasibilities of daylight being admitted and controlled through "top lights" of various forms.* New units use skylight type of glass block, particularly designed for proper transmission and refraction characteristics and set into frames suitable for roof installation. See Fig. 10c.

Vision strips below glass block wall fenestration can present a problem in glare and brightness control. A new 25 per cent transmission neutral glass has been introduced for such use. It reduces normal window glare without introducing color to the transmitted light. Similar glare control with a low transmission acrylic plastic sheet fenestration was illustrated in last year's Progress Report.

*Plastic bubbles for toplighting were referred to last year.

Figure 7. Newton, Massachusetts, typical classroom. All-plastic shielded luminaires meet I.E.S. brightness recommendations.

Figure 8. Corrugated plastic section ceiling is a new adaptation in school lighting.

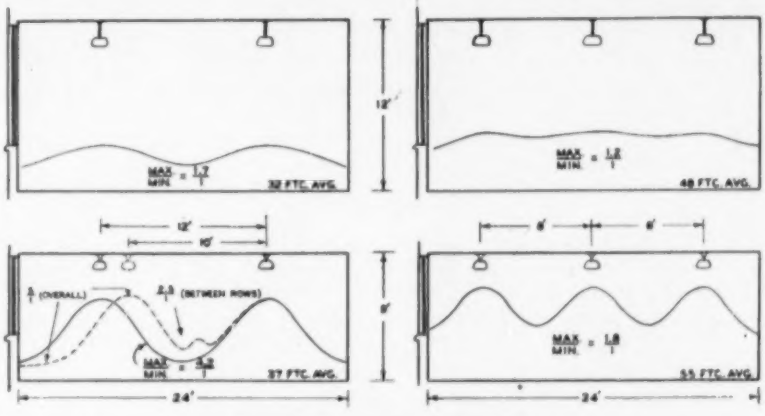


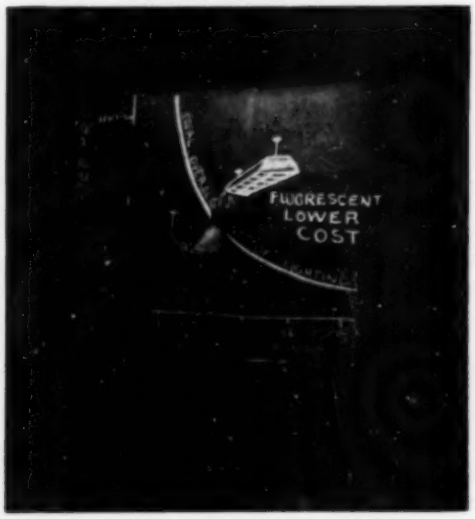
Figure 9. Low-ceiling classrooms pose a special problem for designers and lighting engineers.

Photos: Reynolds Photography, Inc.

Figures 10a and 10b. (Above and below) University of Minnesota High School classrooms have 9-foot 9-inch ceilings; 3-foot vision strips with external baffles used in lieu of conventional windows or directional glass block. Three rows of fluorescent luminaires produce 30 footcandles.

Figure 10c. (Above) Toplighting in a classroom at the University of Michigan.

Figure 11. (Below) Blacklighted chalkboards are a helpful teaching aid.



Blacklighted chalkboards, on which writing is done with fluorescent chalk or crayon, were reported this year. This technique is useful for presenting data under darkened room conditions, as when slides or films are being shown or science demonstrations are being made. The dramatic effect is obtained by using the 40-watt T12 Blacklite Blue (or BLB) lamp in a parabolic polished reflector. Commercial units for this application are now available. Fig. 11 indicates how this may be used with a portable or easel type board for lecture or demonstration purposes.

Store Lighting

Merchandising has always been a fast-moving, fast-growing, and fascinating field. The more than 2,000,000 merchants in these United States are ever alert for new methods and new equipments that will make their stores more attractive and more efficient. It is here that we find a great readiness to apply the new tools and techniques of lighting. In 1953, this use for novel lighting equipment is seen in shopping center development and display technique.

There is a continuing and accelerating movement toward the grouping of stores in shopping centers. The convenience of one-stop shopping, of plenty of parking space and easy accessibility brings customers by the thousands. The resultant high volume increases store efficiency, and can bring lower prices and better value to the buyer. Shopping centers take many different forms. We hear most about the very elaborate ones that contain one or more department stores. But the neighborhood type is far more common.

The Van Aken shopping center in Shaker Heights, Ohio is perhaps typical. Here we find over a dozen stores grouped together, selling everything from groceries to eyeglasses; and the choice of lighting systems and patterns is almost as diverse. Both supermarkets in this center use similar lighting patterns: a combination of two-lamp bare-tube luminaires, with strategically placed 150-watt PAR-38 spotlights and excellent perimeter lighting. In their older stores, Deluxe Cool White was used in the rows nearest to meat cases and produce displays. Now Deluxe Cool White is used throughout the store in the interest of simpler maintenance and good appearance of the live-

ly colors on labels and packages.

An all-fluorescent installation, Bruck's Automobile Showroom in Los Angeles (Fig. 12), shows use of a luminous ceiling. Two-foot square panels of formed plastic provide a uniform ceiling brightness which fills out the polished automobile bodies to nearly uniform brightness by reflection. Attractive low-brightness highlights are created in the chrome trim. The maintained illumination is 85 footcandles.

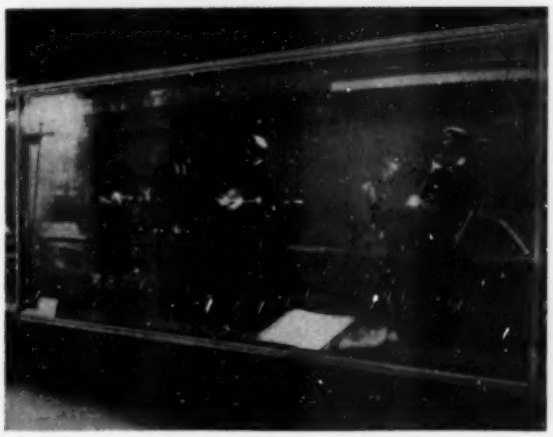
Figure 12. Modular luminous ceiling provides 85 footcandles for display room.

Narrow-beam projector spotlamps are contributing to more effective and versatile show window lighting. They also make it easy to overcome the daytime reflections that so often obscure the shoppers' view of merchandise. Three daytime photographs of a show window at Filene's in Boston (Fig. 13) illustrate the problem and a solution. Fig. 13a shows how completely the display is obscured when no lighting is used. The sign and display of a store across the street are as prominent as the merchandise itself. Fig. 13b shows a slight improvement: 1000 footcandles of general fluorescent lighting reduce reflections a little. However, this is not nearly enough to compete on even terms with daytime brightnesses. Fig. 13c shows that this well-composed display is now effective in attracting the attention of passersby: approximately 200 footcandles of general lighting are supplied throughout, and 100 footcandles are used on featured parts of the display. A diversity of equipment is used at Filene's: slimline fluorescent

Figure 13a. (Left) Window reflections constitute a lighting problem.

Figure 13b. (Below left) 100 footcandles of illumination aid in correcting bad reflections.

Figure 13c. (Below) 200 footcandles general illumination plus up to 1000 footcandles of accent spots produce good display lighting.



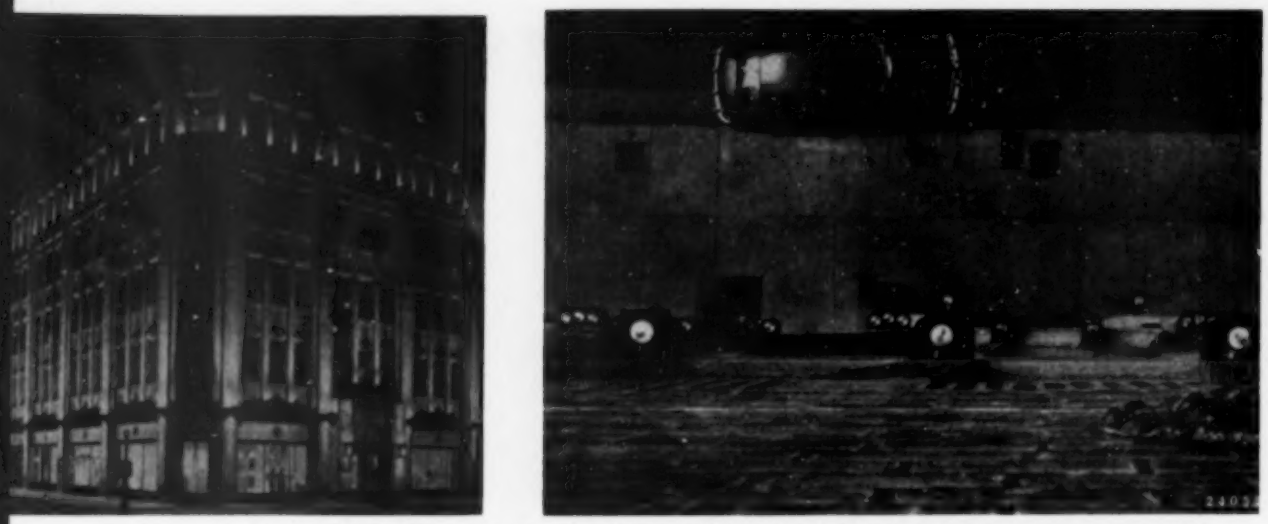


Figure 14. First major lighting display for 1954 Jubilee of Light is the Atlantic City Electric Company building.

for general lighting; 200-watt PAR-46 spotlamps, 6-volt automobile spotlamps, and 150-watt R-40 floods at the window front for high-lighting and additional general lighting; plus 150-watt spotlamps with colored spread lenses in red, green and blue for color effects on window backgrounds.

Electric Signs

The importance of display lighting in the store field is well known to the lighting designer. The store-front sign is part of the merchant's display, even though it is also an advertising medium. There is growing need for the services of illuminating engineers in the sign field. As in other areas, the use of new sources and new techniques is being rapidly developed.

Exposed filament lamps, often used in conjunction with neon or fluorescent tubing, are again achieving an important position in the sign field. Yellow 10S14 lamps are an example, chosen to provide a changing background for the letters by means of flashing effects. This ready adaptability to flashing effects, the availability of a wide range of more efficient and more brilliant colors, and ease of maintenance account for the fast-growing use of filament lamps in signs.

Slimline fluorescent lamps have found a prominent place in the sign field. Mounted behind plastic sign faces, they produce large bright areas that offer an ideal background for many advertising messages. Their advantages of long life, good maintenance of light output at low temperature, easy servicing and ready availability of replacement lamps have led to an estimated use of over one million lamps in this service this year.

Reflector and projector lamps afford another means of obtaining outstanding sign lighting, simply and easily. In addition, building floodlighting effects are often combined with the sign lighting. Sometimes the use of PAR lamps for building lighting can bring out more details of design and impart more interesting character than uniform floodlighting from a few high-wattage sources. The Atlantic City Electric Company installation shown in Fig. 14 makes good use of one of the newer PAR lamp types, the 300-watt PAR-56 floodlamp, to produce interesting floodlighting effects. Narrow beam projector floodlights, aimed straight up, emphasize the vertical lines in the building and the texture of the masonry. The lamps are mounted close to the building in decorative shields; 150-watt PAR-38 spotlamps are used in the units at the building top.

Office Lighting

The importance of good lighting to the efficient operation of offices was given recognition last year when the National Office Management Association adopted the I.E.S. Recommended Practice of Office Lighting as a NOMA Standard. Lighting's importance was dramatically emphasized, too, in the results of tests conducted in the Richmond, Virginia post office shown in Fig. 15. Richmond was selected by the Post Office Department for its test to find what recommended lighting would do for its business of handling the mail. Although the core of this building was used as the Treasury of the Confederate States, the lighting-seeing conditions there are typical of most post offices. Shielded direct-indirect fluorescent units were installed to give about 40 footcandles. (Closed-top industrial units were found to be unsatisfactory.) Paint finishes were lightened and made more colorful. Postmaster McRee of Richmond reports that productivity per thousand man-hours is up about 8 per cent. Future post office lighting plans call for similar quality with units in continuous rows on six-foot centers to give about 50 footcandles.

The introduction of acoustical wedges or baffles in two directional grid patterns is a trend that may be combined with several types of luminous ceiling treatment. The vertical wedges provide shielding action for visual comfort as well as sound absorption. One example is the Thew Shovel Co. lobby, Fig. 16, where four-foot square formed acrylic diffusers are mounted on hinged frames which open or close with light pressure applied to a pair of

Figure 15. "Before" and "after" views of Richmond post office lighting which has upped man-hour productivity by about 8 per cent.

touch-action latches. Diffusers without wedges are used in corridor areas.

Fig. 17 shows a mock-up of elements that were coordinated in developing plans for the new General Motors Research Building. In keeping with the five-foot module of the structure, 60-inch 40T17 lamps are used above the plastic pan diffusers. Sturdy channels may support partitions or carry baffles, permitting great flexibility in office arrangement. The close-up shows the detail developed by the architect, Eero Saarinen, which permits sprinkler head outlets, air conditioning diffusers or other service outlets to be incorporated into the corner couplings.

The General Assembly Building completes the United Nations Headquarters at New York, and the lighting of the great dome of the Plenary Hall (Fig. 18) is as unusual as the architecture of the building itself. The lighting objective for the 750-delegate seating area was to provide good quality general illumination with good distribution, at levels over 50 footcandles at the desks. Structural steel work is exposed in the upper two-thirds of the 75-foot high dome. There 96 down-

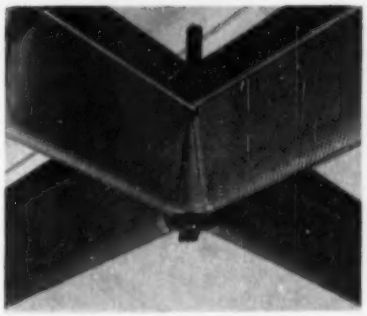
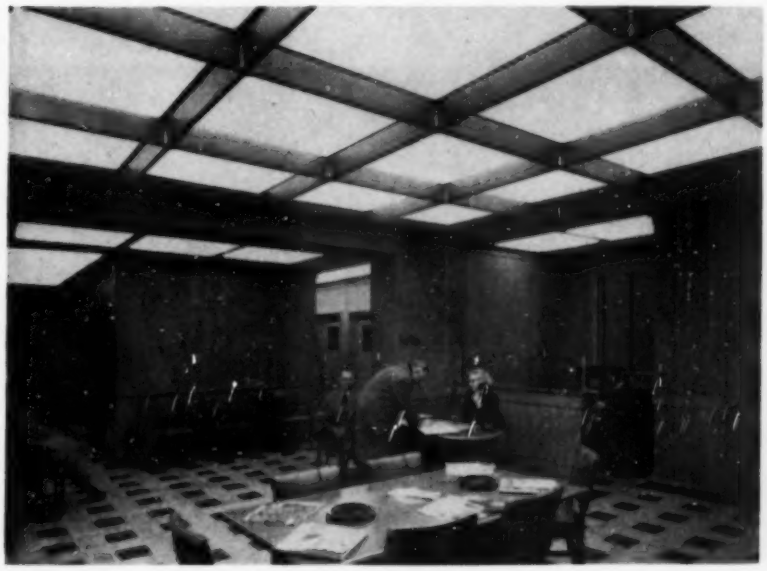
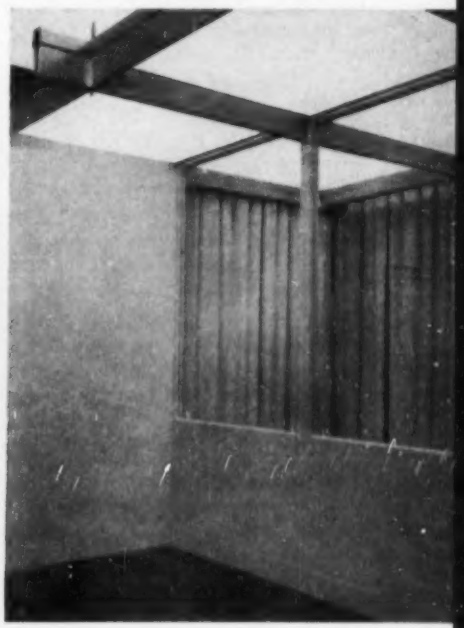


Figure 17. Detail view, above, and mock-up, below, of 5-foot module system permitting utility coordination with baffle wedge construction.

Figure 16. Office area lighted by 48-inch-square acrylic diffusers.





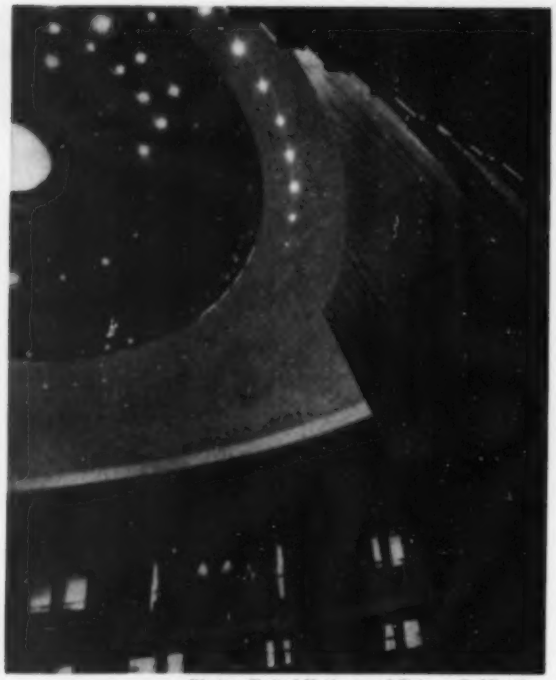


Photo: United Nations and Krieger Publications

Figure 18. Unique downlighting by 500- and 750-watt projectors in United Nations Plenary Hall.

lights are mounted on catwalks at three different levels. The luminaires are finished with a specular Alzak finish inside, and have two baffles, with a band of matte black on the inside at the bottom to reduce the brightness. The openings in the ceiling are eight inches in diameter. Sixteen 750-watt T-20 lamps are used in the luminaires at the highest levels, and eighty 500-watt T-20 lamps on the other two levels. Additional 48 recessed 500-watt luminaires circle the acoustical tile surface around the exposed section. Twenty-four projector units (500-watt T-12 floodlamps with 30-degree spread roundel, adjustable shutter, and condensing lens) light the lower dome surface. To highlight the disc at the very top, four projector spots are located in the dome. This plastered area contains a small circular aperture to admit daylight, this aperture being fitted with a shutter which is closed at night.

Street Lighting

The new 1953 American Standard Practice for Street and Highway Lighting was made available this year. It supersedes the 1947 edition, and is chiefly a clarification of the previous edition, with additional illustrations. Tables have been expanded to include mercury lamps, new and larger filament lamps, and more specific description of light distributions. New appendix material includes "Computation of Roadway Illumination" and "Measurement of Factors in Roadway Lighting." This revision was developed by the I.E.S. Street and Highway Lighting Committee.

An estimated 25 per cent of arterial streets (those carrying more than 150 vehicles per night hour) now conform with the American Standard Practice recommendations. In 1940, less than 2 per cent met these lighting recommendations.

New equipment for fluorescent street lighting, including lamps, ballasts, and luminaires specifically designed for this service, was announced last year. By June, 1953, there were 18 installations—8 completed and 10 more in process—in this country. The new lighting at Oakwood, Ohio (Fig. 19) shows the results with such an installation. The half-mile long, 115-foot wide roadway is illuminated to 1.7 footcandles by 54 luminaires mounted 30 feet above the pavement.

Various important facts regarding street lighting today are contained in a report from the American Public Works Association covering 276 cities, ranging from Mt. Vernon, Texas, population 1000, to Detroit and Philadelphia. Group replacement of lamps was made in 43 per cent of the cities with the trend in this direction, except for mercury lamps. Forty-five per cent of the municipalities said mercury vapor lamps were higher in operative cost, 55 per cent said the cost was lower than with incandescent types.

All but two communities reported that the mercury street lighting improved traffic safety. The opinions, of course, were those of the person reporting and do not necessarily reflect official municipality thinking. Twenty-seven per cent said that color complaints were made by merchants about

Figure 19. Oakwood Ohio installation of F100T12 rapid start street lighting luminaire.

Figure 20. Shielded mercury lighting unit for control of upward light, particularly for airport applications.

the clear mercury lamps, and 90 per cent said public reaction to mercury was favorable. Only five communities indicated that no more mercury installations would be made. Thirty per cent of the communities not now using mercury are planning such installation. Fluorescent street lighting is too new to be surveyed adequately in the report.

Street lighting luminaires are useful in other special applications; tunnel and underpass lighting is one example. To avoid dangerously abrupt adaptation changes, traffic and lighting engineers have established the need for daytime brightnesses of underpass walls and ceiling of about 15 footlamberts. To produce this brightness in tile-walled tunnels requires only moderate illumination of the order of 25 footcandles, but in a concrete tunnel 100 or more footcandles may be required. Searching for suitable luminaires to produce this high level, several engineers have turned to closely spaced mercury vapor streetlights.

Another example is for lighting of airport parking areas and shopping center plazas. A mercury vapor street light is used in this application to provide uniform, adequate lighting yet shield the luminaire brightness from the pilot's view (Fig. 20). This combination is also used to light roadways in the areas.

A deluxe shopping center parking area in Milwaukee uses the same luminaire (without the upward light shield) to uniformly light the area from relatively lower mounting heights than would be practical with floodlights.

Along more conventional lines, but at high levels of illumination, mercury and fluorescent mercury streetlighting luminaires are being applied in turnpike toll plazas. Often fluorescent mercury is used to complement the fluorescent tube color used under the toll house roofs.

Luminaires

Emphasis on luminous, louvered or partly luminous ceilings has continued to grow with increased importance placed on use of standardized parts or sizes of elements. Module systems have been developed with extreme flexibility, some permitting rapid and simple rearrangement of luminous patterns after installation. Combining 2 x 2 foot and 2 x 4 foot elements of luminous plastic, glass or louvers with similar elements of acoustical fiberglass, rearrangement is accomplished by insertion from below.

Along different lines, a fluorescent luminaire has been produced utilizing a completely new approach to the control of louver brightness. Transverse louvers, essentially flat, are designed to depress the candlepower to reduce brightness at higher angles when the unit is viewed longitudinally. As shown in Fig. 21, segments of a parabola are stamped into the reflecting surfaces of the louvers, somewhat similar to the long-familiar fresnel lens. Parabolic control is obtained, yet basic flat baffle form is retained.

Somewhat more specialized in application is a new fluorescent "V" corridor luminaire utilizing integrally louvered molded plastic panels to produce a wide spread across the corridor with low brightness when viewed along the corridor. Forty-five degree louver panels are set at 45 degrees on each side of the unit to produce the distribution indicated.

Ease of accessibility is demonstrated in a new type luminaire which features a terminal block construction that enables the service man to remove the entire luminaire with ballast, sockets and lamp from the luminaire channel. Fig. 22 shows the disconnect method that makes this a practical approach to simpler maintenance.

In the incandescent field, there is expansion of the use of plastics in a concentric ring luminaire incorporating the first one-piece injection molded plastic louver assembly for the three-ring unit. The entirely luminous structure is designed for use with 300-500-watt silvered-bowl inside frosted lamps.

The trend toward improved industrial lighting quality continues with further emphasis on improved brightness ratios. In this connection it is worthy to note that at least one manufacturer has started publishing "Glare Factor" tables (by the Harrison-Meaker system) for all luminaires, making it possible to predict to at least some extent the degree of comfort to be expected from an installation.

Additional fluorescent luminaires have been introduced providing a substantial upward lighting component and even in the incandescent and mercury field such units have become available. The fluorescent mercury low bay luminaire (Fig. 23) not only produces a substantial upward lighting component but follows the increasing emphasis on simplified maintenance and use of long life color corrected mercury lamps. A readily detachable

Figure 21. (Below) Parabolic segments stamped into louver reflector surfaces give lower brightness effects.

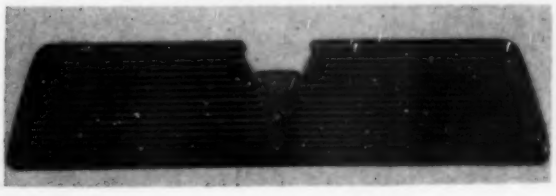


Figure 22. (Right) Disconnect terminal block simplifies luminaire maintenance.

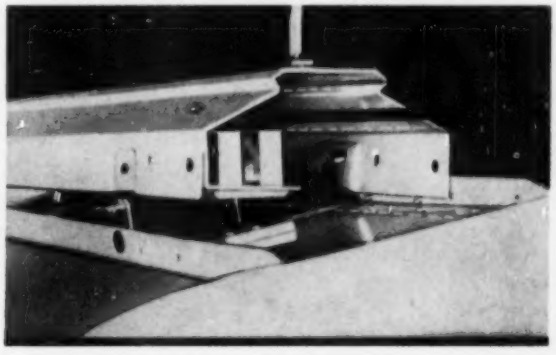


Figure 23. Low-bay mercury luminaire has spun on aluminum cover over prismatic reflector.

reflector assembly permits maintenance at floor level. A ventilated socket yoke supports the efficient prismatic reflector and permanently spun-on aluminum cover.

The above mentioned emphasis on simplified maintenance is worth noting, particularly in that substantiating data have appeared in technical literature confirming marked improvement in light output when adequate ventilation is provided in lighting equipment. Practical tests have demonstrated that both fluorescent and mercury or incandescent luminaires remain cleaner longer when air is permitted to circulate freely over the reflector by convection. The April 1953 issue of ILLUMINATING ENGINEERING contained a paper on this subject.

Along more specialized lines, a luminaire for metal press lighting has been developed. Basic design and development was accomplished by the Lighting in Sheet Metal Stamping, Folding and Shearing Industry Committee of I.E.S., Mr. Floyd Sell, Chairman.

Increasing interest in fluorescent street lighting has followed the introduction of a four-lamp luminaire of special design. This uses the F-100T12 rapid start fluorescent street lighting lamps reported last year and incorporates the largest injection molded acrylic plastic cover ever used. Integrally louvered plastic baffles are also included. A number of installations have been made in which a large business area is lighted by these luminaires (Fig. 19).

Another new type of street lighting unit (Fig. 2a) uses the highest lumen output sources available for street lighting, the 700- or 1000-watt mercury or fluorescent mercury lamps. Unique light control features utilize an optical assembly combining an asymmetrical reflector, patterned diffusion in the globe and selected tilt of the entire assembly to produce a Type IV distribution. It is particularly adapted to lighting white way areas, heavy traffic boulevards and other areas requiring high levels of illumination.

Ballasts and Circuits

Probably the most significant occurrence during the past year of ballast development has been the preparation of the Certified Ballast Makers specifications for series and lead-lag rapid start ballasts for 40-watt fluorescent lamps. Ballasts have been certified by the Electrical Testing Laboratories under these specifications and incorporate safety requirements proposed by the Underwriters' Laboratories.

Single, two-lamp and four-lamp type ballasts are offered in greater variety. One manufacturer has a special unit that permits a wide choice of lamp combination by choice of output leads. A new two-four ballast has appeared which is designed to operate a variety of slimline lamps in assorted combinations; for example, two 48T12 plus two 42T6 may be operated, or the same ballast will operate four 42T6 or two 96T12 lamps. This makes possible considerable simplification, as, for example, in the sign industry. A four-lamp series mid-point ballast for LP or HP cold cathode lamps has been announced.

Two years ago the Progress Report described the Beltsville Agricultural Test Station experience with 360-cycle fluorescent lamps. A commercial model Static Frequency Converter has been announced. A 5-kw converter provides 360-cycle square wave current at 600 volts and can operate up to 80 eight-foot slimline lamps using only a capacitor (0.21 to 0.39 microfarad) to ballast each lamp. Current through the lamps may be readily varied from 300 to 500 milliamperes if the number of lamps is held to 50 per converter.

A new system for operating mercury street lights is in its first application.

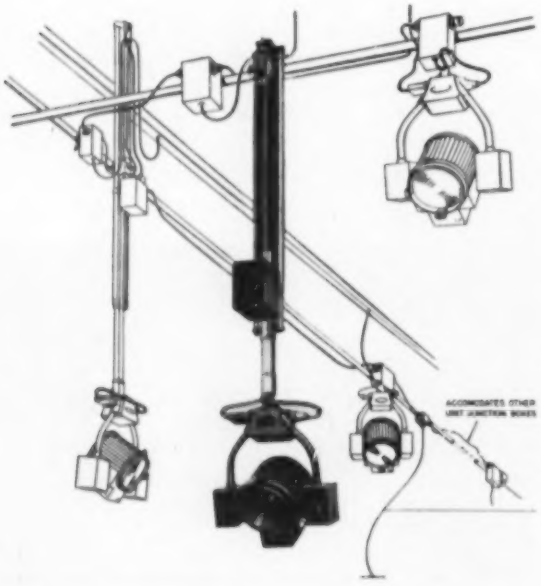


Figure 24. New remote control system using light-weight fresnel spotlights with compact portable console.

This uses control and power supply devices of unique design that permit straight series circuit operation of 400-watt mercury street lamps with a minimum of equipment space requirements.

Two new types of theatrical control circuits are now available. In one system (Fig. 24) electro-mechanical gearing makes possible complete remote control through 360-degree "panning," 180-degree "tilting," raising or lowering in a 6-foot range, focusing with respect to the lens, switching preselectable groups, mechanical dimming and on-off control. This uses a new design light-weight fresnel spotlight in an ingenious assembly controlled by a small console that can be remotely located to suit the operator. The second system (Fig. 25) employs miniature electronic control components to handle standard forms of stage lighting sources with practically unlimited flexibility. As many as 10 pre-set lighting cues involving all stage lighting equipment can always be prepared ahead of the performance, and all dimming and color combinations are instantly available at the operator's command as scene changes occur.

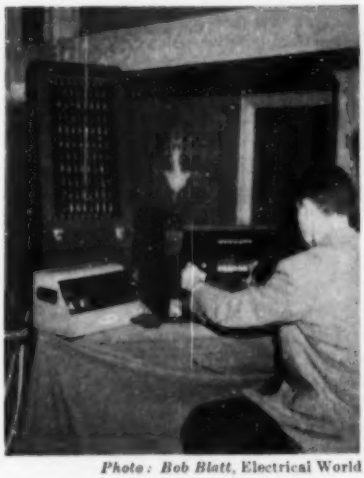


Photo: Bob Blatt, Electrical World

Figure 25. C-1 all electronic system components used in Progress Report presentation.

Residence Lighting

The last two years have been extremely successful ones in accelerating recognition of lighting's influence on family living. A milestone in clarification of the home's lighting needs and purposes was made with the Residence Lighting Committee's 1951 Report on "The Functional Visual Activities in the Home." In 1951 and 1952, the Society distributed 10,000 copies of the Residence Committee's 1950 Report "Contemporary Lighting in Modern and Traditional Interiors" — the first Society expression to residence architects, interior designers and lighting consultants on the many ways to harmonize principles of good design and good lighting. Committee work on these two progressive projects created an important cornerstone of an entirely new Recommended Practice for Residence Lighting (1953)—one which is for the first time highly definitive and specific in how to attain its recommended illumination, brightness and brightness-ratio recommendations. This same committee also prepared a Residence Lighting Resource List for educators, home advisors and students of lighting for the home to fill a growing demand for current authoritative sources of information.

A new philosophy in designing and merchandising lighting equipments for the home is apparent. A higher sense of combining good styling, related to current home furnishings, with good lighting related to specific home visual tasks, is to be noted. Already over 1000 lamp designs from more than 100 manufacturers have been approved by interior designers for appropriate styling, and by lighting specialists for appropriate lighting. Where and how they apply in homes for greatest usefulness to the family will be shown in industry-sponsored Lamp Fashion Shows to be held throughout the country this fall and coming year. An experimental preview was held in a midwestern city this past summer. It is anticipated that better distribution, display and merchandising methods can and will evolve from this endeavor. Thus consumers may be assisted in finding the less complex and more satisfying lighting answers they seek.

Special credit must be given to the editors of the home and women's magazines and to the progressive builders for the major role they have played this past year in lighting's progress. Outstanding, in editorial space devoted to lighting, was the July issue of *House Beautiful* containing a 36-page portfolio on "The Growing Art and Science of Good Seeing." Fig. 26 shows clearly that this idea originated in the Society's Report on Visual Activities. Already recorded — and there are undoubtedly many others — are 250 builders who have in the last two years displayed new homes which were featuring lighting in accordance with this same report. These builders have seen the appeal better lighting has to the public and learned that with more realistic fixture allowances, they can equip modest-priced homes with a quality lighting long associated with the very costly home. Fig. 27 shows a modern home, under $15,000, in which a 24-foot wall-to-wall cornice with De-

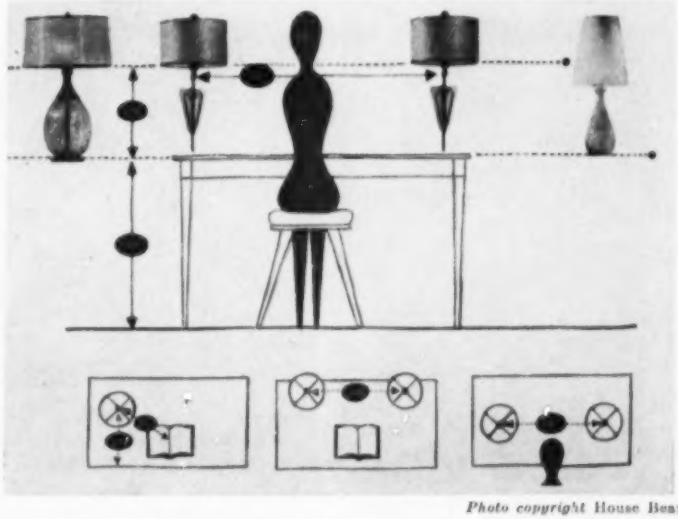


Photo copyright House Beautiful

Figure 26. Home magazines are doing a bigger and better job of telling homemakers how to use light. Reprinted from July *House Beautiful*.

Figure 27. Small home builders are sensing the consumer appeal in wall-to-wall fluorescent elements in living areas.

luxe Warm fluorescent lamps extends the length of the living-dining area for background and special occasion lighting. The table lamps used three 60-watt lamp bulbs placed horizontally between a large plastic diffuser below and a perforated metal shield above. In the small bedrooms 6-foot fluorescent brackets were applied at the top of the closet sliding doors to provide specific lighting there and for general room lighting. While that excellent new technique, the luminous ceiling, may be too costly for the average new home, it does have very practical application in renovating the old high-ceilinged homes. Fig. 28 shows a good example in a remodelled combination kitchen, pantry and dining space.

With 160 million persons in this country and about 45 million homes, it is obvious the attainment of Society goals for better home living through better lighting for even the majority is far in the future. But the need is clear, from the impetus gained so lately, to strengthen Society leadership for broader participation in its objectives. The home lighting workshop is one way to implement this aim.

Hailed as the first course on home lighting ever approved for upper division college credit, as well as the first home lighting institute ever held on the Pacific Coast, a five-day "Home Lighting Workshop" was held in San Francisco, California, June 15-19, 1953. San Francisco State College offered the short course, with one unit of college credit, in cooperation with the Northern California Electrical Bureau and the Northern California Section of the Illuminating Engineering Society. Mrs. Marguerite Fenner, director of Home Economics for the Pacific Gas & Electric Company, conceived the idea and promoted her dream to a most successful conclusion. Of the 190 who attended, 101 were teachers who paid a fee of $7.50, and received one unit of upper division college credit for the week's attendance. It is believed that the success of this venture will induce other colleges and I.E.S. Sections and Chapters to offer a similar course to further the growing interest in residential lighting on the part of educators.

"Lighting for Better Living," a new program of educational materials for teaching about light and sight in high school home economics classes was prepared by the Home Lighting Education Committee of the Better Light Better Sight Bureau with advice from top leadership in the home economics field. Following the footsteps of the Bureau's elementary and junior high school programs on light and sight, "Lighting for Better Living" makes available the same type of authoritative information but on a higher level. It is expected that the program will find wide acceptance in high school home economics classes and also in extension classes in home economics. Program materials include a source

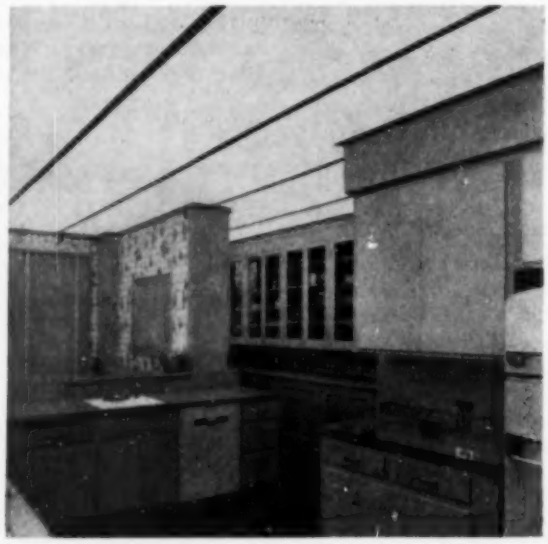


Figure 28. Luminous ceilings find acceptance in both new and renovated homes in bathrooms, sunrooms, libraries, entrance halls and kitchens. In this installation 65 footcandles is provided by seven rows of six Deluxe Cool White fluorescent lamps mounted on the original 11-foot ceiling. The corrugated plastic is hung at 9 feet 3 inches over a total area 18 feet by 25 feet. Flexible switch control allows lighting at four separate centers and an incandescent color wheel introduces a variety of effects for the dining area.

book for the teacher, study leaflets for the pupils, 16 large easel-mounted charts, an activities book, a program book describing the materials and how they might be used, and a copy of the National Education Association's "Teaching about Light and Sight."

Lighting Education

A list of some month by month educational activities will indicate the broad scope of Society influence in Section and Chapter support of lighting education:

July '52 — Illinois Summer Workshop on Occupational Vision Studies; Chicago Clinic on Street and Highway Safety Lighting; New York Design Competition; Miami Beach American Optical Association meeting on "Seeing in Schools."

August '52 — I.E.S. report on Illumination Courses in U. S. and Canada.

September '52 — Lighting Fundamentals Course in New York.

October '52 — Cleveland TV Studio Lighting Clinic; Philadelphia Lighting Fundamentals and Lighting Design Courses.

November '52 — Chicago Lighting Institute Courses; University of Wisconsin Illumination Institute; Washington, D. C. Advanced Applications Course; New England Course on Lighting Fundamentals.

December '52 — University of Michigan Conference on Industrial Design; Cleveland Plant Maintenance Conference; Buffalo Wiring and Illumination Course; Pittsburgh Illumination Course; Chicago Clinics on Farm and Home Lighting and Light in Photography.

January '53 — Rutgers University Occupational Vision Conference; New England Street Lighting Course; Chicago School Lighting Clinic.

February '53 — Chicago Clinic on Lighting for Merchandising, New England Advanced Course.

March '53 — Kansas City Lighting Fundamentals Course; Chicago Industrial Lighting Clinic.

April '53 — Hamilton, Ontario Fundamentals Course; 6 Holophane scholarships established at University of Illinois; Cleveland Allied Arts Competition.

May '53 — University of Detroit Student Seminar on Light; Arizona Course in General Illumination.

June '53 — San Francisco Home Lighting Workshop; Univ. of Michigan Light and Vision Conference.

It is understood that this list is not complete but it is informative. Many other educational activities have been promoted by our members.

ILLUMINATING ENGINEERING included pages of Questions and Answers prepared by the Committee on Light Sources.

Light Control Devices and Materials

Among light control devices new designs of prismatic lenses for general and specialized applications continue to appear on the market. One manufacturer has brought out a square prismatic lens extending slightly below the ceiling line, especially designed for the incandescent lighting of extended areas, such as corridors, aisles, and counters. Another company's new product in this line includes a general lighting lens for use with incandescent lamps whose curved contour and slight extension below ceiling level assure a certain amount of upward light, together with high efficiency and low brightness of light distribution in downward directions.

For light control of fluorescent lamps, a low brightness prismatic lens has previously been introduced and described. This principle is gaining wider acceptance, one manufacturer now supplying such a prismatic pattern in rolled glass of large dimensions up to 24 inches in width and 100 inches in length. Further, the use of fluorescent prismatic lenses made of acrylic plastics is increasing, four different designs being commercially available at present.

In daylighting, the familiar glass block has taken on a new task; two companies have brought out such glass blocks to be installed in the roofs of buildings for top lighting applications as an up-to-date version of skylighting (see Fig. 10c). Also, a neutral plastic laminated glass product has been introduced to eliminate the necessity for added shading devices in window glazing.

In the field of light measuring devices, one manufacturer has designed and built a photometric laboratory housing a photometer suitable for accurate testing of present-day large commercial, industrial, and street luminaires using fluorescent and mercury vapor lamps. This photometer employs a clear test distance of 25 feet, both vertically and horizontally, so that the units on test can be operated under actual application conditions (Fig. 29). As both the movement of the photometric cell on the 25-foot arc and the rotation of the test unit in the photometer head are carried out by remotely controlled electric motors, the photometer is adaptable to the operation of automatic recording mechanisms. Also, this feature permits the test room to be in complete darkness,

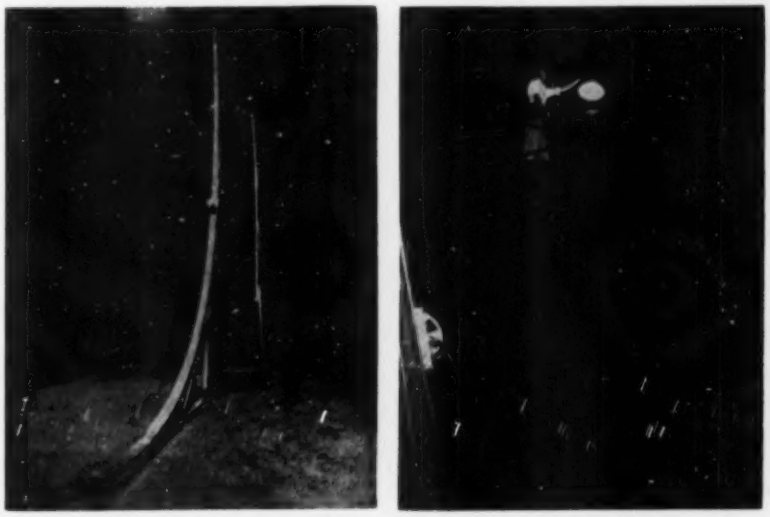


Figure 29. Movement of photoelectric cell on 25-foot arc and test unit motion in new photometry laboratory are accomplished by remote controlled motors.

Figure 30a. World War II searchlight trailer generator and trucks.

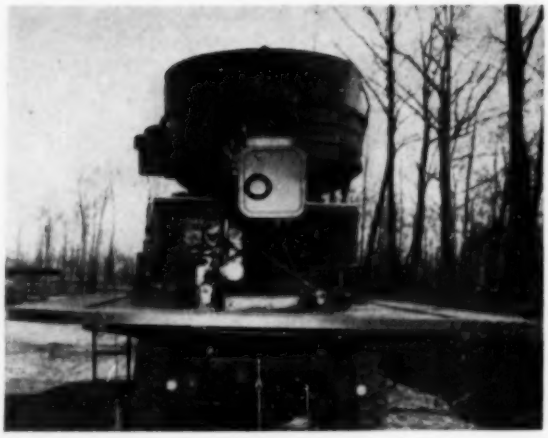


Figure 30b. (Left) New truck-mounted searchlight in traveling position.

Figure 30c (Above) Truck-mounted searchlight in operating position.

except for the unit to be tested, the operator being in an adjacent, fully lighted room. This is of advantage in coordinating test work with luminaire design.

Another manufacturer reports completion of a single axis recording goniophotometer, containing a phototube and recording millivoltmeter, to measure the diffusion of translucent materials. The brightness of a given area of a test sample can be measured and recorded at various angles to the surface. The instrument can also be used to measure and record diffusion and directional effect of fluted transparent material, such as clear ribbed glass.

In order to obtain rapid evaluation of optical control elements and distribution characteristics of complete luminaires, one photometric laboratory has installed an automatic recording photometer producing polar curves as well as rectangular coordinate data. Both curves may be run in a matter of minutes. One recorder draws a curve on rectangular coordinates for greater accuracy of calculation while a second recorder charts a polar curve of familiar type which may be quickly evaluated visually for distribution shape. Considerable time is saved for design engineers since curve data do not have to be plotted by hand.

A novel streetlighting visibility meter has been designed by Prof. D. M. Finch, which he described in detail in a paper presented by him at the 1953 I.E.S. Technical Conference (see ILLUMINATING ENGINEERING, October 1953).

In the field of portable light meters, a new meter has been introduced in which the usual clear glass cover has been replaced by a plastic lens plate with a special grid pattern. This special cover lens provides cosine correction so that light striking the plate at oblique angles is properly recorded by the light sensitive cell. In addition, the new light evaluator is provided with a filter for color-correction.

An interesting application of the use of light in a field rather remote from the lighting industry is the use of an electrical-optical "brain" developed to give instant data on how fast an airplane "hits the deck" or lands on aircraft carriers. To measure the rate of descent of an airplane, this device sends out two parallel beams of light one foot apart. Mirror systems on the incoming airplane cut into these beams and reflect them to a photoelectric cell which controls an electrical charge into a condenser. This electrical charge is then translated quickly by the instrument from voltage to rate of descent of the plane in feet per second.

Military Developments

Truck Mounted Searchlights

The World War II 60-inch antiaircraft searchlight was designed to be transported in a special covered trailer towed behind a 2½-ton truck. The power plant was also trailer-mounted for towing behind another 2½-ton truck. Thus it took two trucks and two trailers to transport one searchlight, Fig. 30a. These searchlights are no longer used against aircraft but are now used extensively for battlefield illumination. In Korea they were placed so close to the front lines that they had to be moved into position each night and out again each morning. In addition they frequently were required to move during the night. It was obvious that the trailers were inadequate and better transportation was necessary.

The Corps of Engineers solved this by mounting searchlight and power plant on a 2½-ton truck, Fig. 30b. Special springing is provided for the searchlight and the truck sides let down to make a platform for the operator, Fig. 30c. This searchlight truck has proved extremely successful and is now standard equipment.

Battlefield Illumination or Artificial Moonlight is provided by these searchlights by locating the lights 5 to 10

Figure 31. General Patton tank (M-46) with 18-inch shuttered, incandescent searchlight.

thousand yards behind the area to be illuminated and then directing the beams at a low elevation over the area. Light scattered from the beam provides illumination equivalent to a partly full moon. Because the light is directional and under their control, friendly troops are given considerable advantage over the enemy. The enemy has also found that it is not possible to neutralize the light by gun fire because it is extremely hard to hit a searchlight.

Fighting Light for Armored Vehicles

Early in the Korean War it became apparent that night attacks of the enemy could best be countered with the aid of illumination. To assist in solving the illumination problem, a number of eighteen-inch incandescent searchlights for tank mounting were fabricated and sent to Korea for use and evaluation where they proved to be highly successful. Fig. 31 shows this searchlight, equipped with an eighteen-inch Alzak mirror, a 2000-watt incandescent lamp and a shutter for quick extinction of the light beam. The peak intensity of this searchlight is *2 million candles* and the beam spread is approximately *4 degrees high by 8 degrees wide.*

Fluorescent Panels

Fluorescent panels were procured by the Corps of Engineers as a possible solution to the problem of indicating ground positions to night-flying aircraft. These panels are similar in appearance to the 30 x 144 inch cloth signalling panels used in daylight, but are especially fabricated for high brightness under ultraviolet "black light" radiation. The panels are made in a variety of colors for easy identification. The panels are activated with commercially available, battery-powered, 4-watt fluorescent "black light" lamps in small housings mounted on stakes.

Reflectorized Phosphorescent Material

The Corps of Engineers has developed a new sheeting material which combines the properties of *retro-reflection* and *phosphorescence.* This material can be used for articles of clothing such as leggings, belts and arm bands, for signs, for road marking and for vehicle marking. It can be seen by phosphorescence under complete blackout and by reflection when use of light is permitted. The material can be made with either fabric or plastic backing. After many tests the striped pattern was found to be the most efficient in obtaining the highest possible brightness for both reflection and phosphorescence.

Radioactive Marker Buttons

In World War II and in Korea, small radium-activated, luminescent buttons were used extensively for marking personnel, paths, bridges, and obstacles. Although the buttons were well shielded, the gamma radiation from the radium was hazardous especially when the buttons were shipped and stored in quantity. The Atomic Energy Commission has produced a number of artificially made radioactive isotopes among which is an isotope of strontium. This isotope, strontium-90, emits beta rays only, which can be shielded effectively. The radium button has a surface radiation of 25 milli-roentgens per hour which would exceed the maximum human daily tolerance limit in a few hours. The strontium-90 button has a surface radiation of about 2 milli-roentgens per hour which is below the tolerance limit for continuous exposure. The strontium-90 buttons have a brightness which meets the same specifications formerly used for radium buttons.

Beam Splitters and Filter Mirrors

Beam splitters which are practically non-absorbing can be made with almost any proportions of reflectance and transmittance. They are produced by evaporating quarter-wavelength films of alternate low and high refractive indices. In the case of highly reflecting beam splitters, additional half-wave coatings are necessary to make the beam splitter neutral with respect to color. Dichroic beam splitters can also be made which reflect and transmit different colors strongly.

Selective reflectors can be produced by evaporating a reflecting metal surface and then evaporating additional quarter-wavelength films which by a combination of absorption and interference can reduce the visible reflectance of the reflector while the infrared reflectance remains at a high value. These selective reflectors are useful for decreasing unwanted visible and near infrared radiation in infrared components.

Lighting in Europe

The foreign correspondent members of the Progress Committee have been thorough and very cooperative and the chairman wishes to express his appreciation for this part of the report to:

Mr. Jean Chappat
Compagnie des Lampes
Paris, France

Mr. L. C. Kalff, Gen'l Art Director
Lighting Service Department
Philips Company
Eindhoven, Holland

France

Figure 32. French airplane cabin lighting with molded plastic luminaires using 14-watt Warm White fluorescent lamps operated on 52 volts direct current.

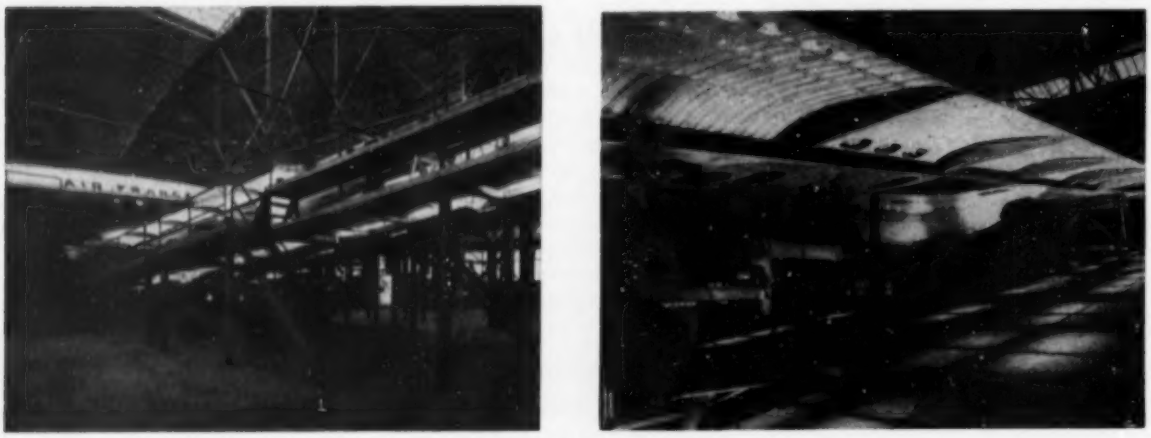
Mr. Ivar Folcker
Swedish Lighting Association
Stockholm, Sweden

Mr. E. B. Sawyer, Manager
Lighting Service Bureau
Electric Lamp Manufacturers Assoc.
London, England

France

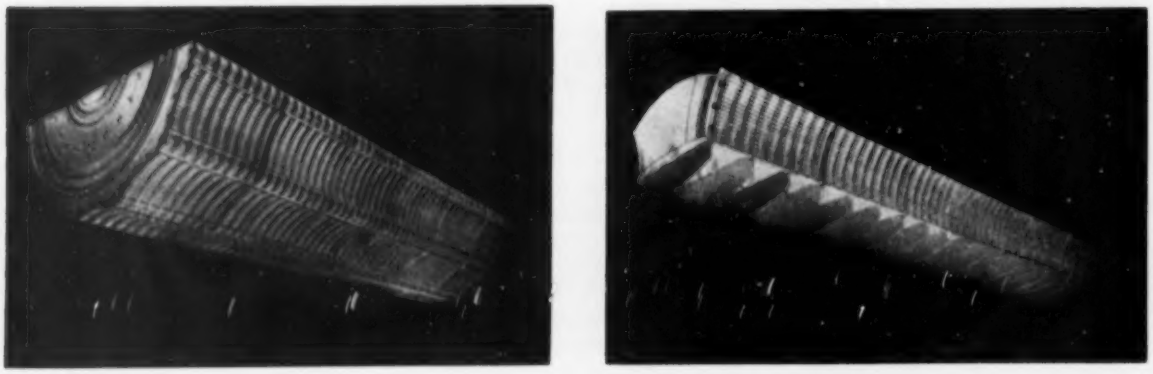
One French manufacturer has placed an incandescent lamp on the market, similar in shape to the American "A" lamps; this bulb has a special frosted glaze over two-thirds of the surface, leaving a clear dome. Projection lamps are reported for the first time in a 3200K color temperature designation for use with Technicolor or Gevacolor film.

A new type of ceramic condenser, .006 microfarads, for fluorescent start-



France

Figure 33. Maintenance plant of Air France at Orly Airport near Paris. Forty-watt white lamps in suspended industrial reflectors under the metal grid work platforms give good local work surface lighting.



France

Figure 34. Two examples of molded plastic luminaires from France.

France

Figure 35. (Left) Dramatic lighting of circular staircase using both direct and indirect incandescent units with prismatic lens in the luminaire. Installation at Metal Research Institute, St. Germain, near Paris. And Figure 36. (Right) Hospice de Beaune (Hotel Dieu), Burgundy, lighting for A.F.E. Congress. Photo by Mr. Chappat.

ers is said to be watertight and particularly useful in humid atmosphere to give dependable starting.

The use of molded styrene-type plastic louvers and shields offers the architect, decorator and contractor many combinations of luminaire designs using standard parts suited to given conditions. See Fig. 34.

A committee of the A.F.E. (l'Association Française des Eclairagistes) has published, for the first time, a Recommended Practice "for the illumination of buildings and their annexes" (Recommendations Relatives à l'Eclairage des Bâtiments et de leurs Annexes). This includes late results of American and English studies and provides a chart of recommended lighting installations together with minimum lighting levels which present economic conditions make possible in France. The work has been approved by the French Committee on Lighting (International Committee of the C.I.E.) and by the National Institute of Security, which is concerned with industrial applications.

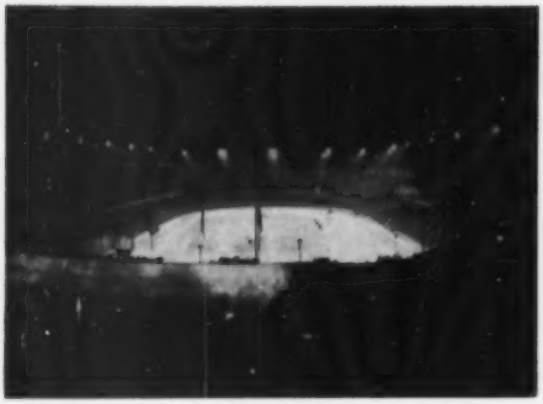
The annual Congress of the A.F.E. met in 1953, at Dijon, on May 12 to 16. Over 300 persons participated in the convention. Dr. Ward Harrison, President of C.I.E., attended and Mr. E. W. Beggs spoke on American trends in the use of discharge lighting sources. More than 60 historical monu-

The Netherlands

Figure 37. Experimental streetlighting in the Hague. Fluorescent tube lighting across wet pavements.

Sweden

Figure 38. Floodlighted Jakobs Church and Kungstradgarden in celebration of 700 year Jubilee of Stockholm.



Norway

Figure 39. Bislet Stadium in Oslo, using 210 1000-watt and 60 1500-watt floodlights.

Sweden

Figure 40. Open-top industrial luminaires in a Swedish electrical repair shop.

Finland

Figure 41. Department store in Finland, equipped with pendent incandescent hoods for accent lighting and well-louvered large-area ceiling-mounted fluorescent units.

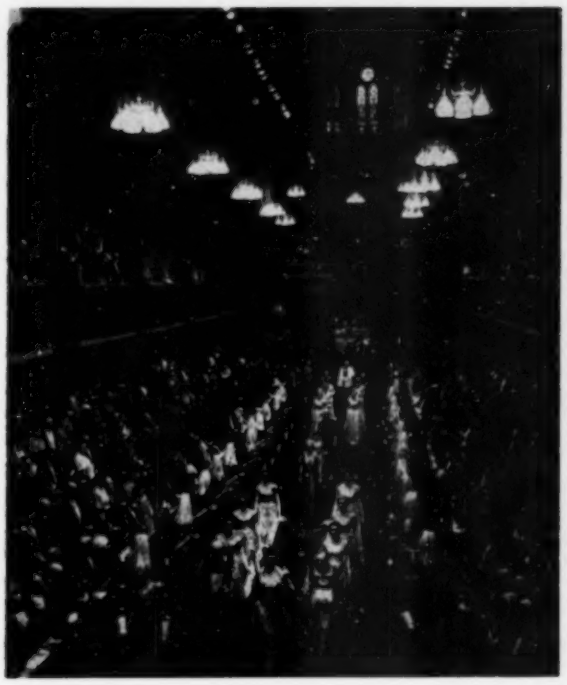
Sweden

Figure 42. Angular mounted fluorescent street lighting equipment gives good results in highway illumination at Mariestad.

Figure 43. Vertical mounted plastic-enclosed street lighting unit using three 80-watt fluorescent lamps, for use on building face or on poles.

England

Figure 44. British fluorescent luminaires mounted on universal wiring channel which also accommodates wiring for loud-speakers, telephones, alarms and machine power, saving conduit.



England

Figure 45. State procession in the Nave of Westminster Abbey after the Coronation ceremony, showing Triforium projectors and refractor luminaires.

Figure 46. The spectacular Mall arches and banner poles lighted by combinations of 75-, 100- and 500-watt reflector spotlights, suitably located in the arch structure.

ments in the towns of Dijon and Beaune, as well as castles in the vineyards of Burgundy, were brilliantly lighted for night display with projector sources. (See, for example, Fig. 36.) The main roads in Dijon were used to demonstrate various forms of incandescent, fluorescent, mercury and color corrected mercury street lighting units.

Netherlands

In April 1953 the Royal Netherland Tourist Club together with the Dutch Illuminating Engineering Society organized a meeting for authorities and engineers responsible for public lighting in this country. Lectures were given by specialists on "Aim and Importance of Public Lighting," "Influence of the Road on the Road User," "Criteria on the Quality of Public Lighting" and "Planning of Installations for Public Lighting." Over 300 people attended the meeting and discussed their problems.

The Hoofdcommissie voor de Normalisatie in Nederland (the permanent semi-official Committee on Standardization in the Netherlands) finished its study of Recommendations and Code of Practice for Daylighting and the booklet is now in print. An unusually well documented paper was released by H. Zijl of Eindhoven on "A New Method for Computing the Illumination on Sporting Grounds and Similar Objects by Floodlight." The method has the same starting point as the utilization curves for floodlights developed by Merle E. Keck (ILLUMINATING ENGINEERING, March 1950) but follows other lines. Says Mr. Zijl, "It is possible to compute with reasonable accuracy the initial horizontal illumination on a horizontal area; illuminated by narrow beam reflectors. From the initial illumination value the approximate operation value can be derived by estimating a depreciation factor. For a given distribution of the beams the distribution of the luminous flux over the illuminated area can roughly be computed."

An experimental streetlighting installation at the Hague, Netherlands (Fig. 37) uses a line of fluorescent lamps placed deliberately to produce a wide bright streak pattern on a wet pavement. The lines are suspended at right angles over the street at intervals of 200 to 500 yards. Over street crossings the lines of lamps are placed diagonally in order to serve in both directions at the intersections. The lamps are operated only when the streets are wet.

Germany

An application of a xenon high pressure lamp is reported for use in the field of color evaluation. This color test unit uses a 160-watt air cooled xenon arc operated on 220 volts a-c and the output is 3200 lumens at an efficiency of 20 lumens per watt. The spectrum is practically continuous in the visible range and quite independent of reasonable fluctuations in supply voltage. Lamp life is said to be about 300 operating hours and not influenced by frequency of starts.

Scandinavia

Stockholm is celebrating its 700th jubilee year and special festival lighting has aided the historical pageantry.

The 1952 winter Olympic games at Oslo were conducted in a new stadium; Fig. 39 gives a good impression of Norwegian sports lighting methods. Both 1000- and 1500-watt floodlights

were used in multiple clusters for broad coverage of the stadium area.

There has been much talk about the significant trend in American industrial lighting which has stimulated the use of upward component luminaires. Fig. 40 shows a view of a Swedish workshop where open top luminaires are applied. These have an all white finish and are equipped with two 40-watt fluorescent lamps. Two other pictures (Figs. 41 and 42) show department store lighting in Finland and fluorescent highway lighting at Mariestad.

England

The English *Journal of the Institution of Municipal Engineers*, April 1953, summarized a study of street lighting practice and planning in 343 communities that participated in the survey. Types of sources now in use were reported as 39.69 per cent gas, 49.78 per cent tungsten filament, 6.67 per cent mercury vapor, 3.37 per cent sodium vapor and .49 per cent fluorescent. Planned installations for the near future indicated a growing preference for sodium vapor and mercury lighting, with sodium having the edge of preference in some cases.

Fluorescent street lighting units mounted on building faces have been used at Birmingham, Eastbourne, Richmond, London and elsewhere. (See Fig. 43.) It is acknowledged that the technique is most useful for narrow streets and it is reported that "the City [of London] is shortly to be relighted by fluorescent lamps, but whether by this means [building face-mounting] or by other means is too early yet to say." Such luminaires contain two or three of the five-foot 80-watt lamps using the normal double contact bayonet bases.

Fluorescent mercury lamps using barium lithium silicate or arsenate are reported to yield 7½ per cent red light as compared to about 4½ per cent for former sulfide powders.

A popular circuit in England today, especially for commercial applications, employs a filament ballast lamp in series with a 40-watt fluorescent lamp with internal starting strip. Another "ballastless" circuit uses a small transformer for electrode heating of the fluorescent lamps which are in series with the filament ballast lamps. These are becoming popular in shops and offices chiefly because of a growing preference in England for mixing filament and fluorescent lighting; the idea of the filament lamp doing two jobs appeals to the majority of the people. Also, the low capital cost is a very strong factor in selling such circuits to the owners of small stores.

Figure 47. The Royal Coach bearing the Queen and the Duke of Edinburgh. Fluorescent lamps light the coach interior.

In British industrial lighting, perhaps the most notable feature has been the continued growth (in large installations) of systems mounted on continuous multipurpose wiring channel (Fig. 44). Details naturally vary, but the typical channel consists of hollow square or rectangular section extruded aluminum or steel with a continuous T-slot formed beneath, along which can be slid square headed bolts holding the luminaires. The sections of the channel may be 12 feet or more in length with suitable jointing pieces. This type of arrangement requires fewer main supports than would be needed for individual luminaires, misalignment is impossible, and luminaires are very simply installed or increased in number, each being plugged into a convenient socket in the wiring channel which may also contain circuits for signals, telephones, etc.

Unquestionably the most outstanding "highlight" of the year in Great Britain was the coronation lighting. Both at the coronation itself and during the subsequent celebrations, lighting played a significant part.

Several difficulties had to be overcome in arranging lighting effects in Westminster Abbey, Fig. 45. Something spectacular but not theatrical was required; a number of television and film cameras were concealed at widely separated points. Each position required directional lighting to suit its own needs but not to interfere with other crews. High intensity was required without excessive heat as the ceremony lasted several hours and thousands of those present had to remain in their places for more than six hours. The dignity of the historic surroundings had to be preserved.

The lighting of the Abbey interior mainly consisted of 144 specially designed 1000-watt projector units using Class B (concentrated-filament, 800 hours life) projector lamps installed at Triforium level (approximately 70 feet above floor level) as shown in Fig. 45. The existing candelabra equipments were adapted to take gold-tinted prismatic reflectors, turned downward, with 500-watt "photo-pearl" lamps on dimmer control in conjunction with the overhead projector floods. 120 foot-candles were delivered over the principal areas. The royal gold carpet covering the entire floor area formed a magnificent setting for the complete lighting environment.

The greatest center of attraction, other than the Abbey, was the Mall, shown in Fig. 46. The four great golden arches were topped by the Lion and Unicorn and supported large but light and delicate crowns. Lighted banners surmounted by crowns lined the sides of the Mall. Concealed reflector spot and flood lamps lighted the arches and poles.

Well-known men in the lighting world to whom Her Majesty the Queen has awarded the Coronation Medal for loyal service to the Crown include Dr. S. English, past-president of the Illuminating Engineering Society (in England) and Mr. W. E. Rawson-Bottom of the Illumination Section of the Ministry of Works, who was closely connected with the Abbey lighting.

New I.E.S. Publications 1952-1953

1. American Standard Practice for Street and Highway Lighting, 1953.
2. Recommended Practice for Supplementary Lighting, 1952.
3. Recommended Practice for Residence Lighting, 1953.
4. Lighting for Foundries, 1952.

Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of H. F. Davidson, has prepared this listing of answers to frequently asked questions. Readers are invited by the Committee to submit similar questions of general interest on light sources, to be considered for publication from time to time. Questions may be sent in care of Society Headquarters.

How much does the lumen output of a 40-watt T12 fluorescent lamp depreciate during life?

The rated initial lumens of a fluorescent lamp are based on the output at 100 hours. Under normal operating conditions, the lumen output in per cent of initial will be as follows:

At 100 hours	100%
500 hours	95%
3000 hours	85%
7500 hours	76%

With the 7500-hour life rating, the lumen output at 3000 hours represents the mean lumen output during lamp life.

It should be emphasized that the above data are a function of the lamp only, and that accumulation of dust or dirt on the lamp and fixture will appreciably reduce the overall lumen output.

What is meant by the term "mean lumen output" as applied to lamp performance?

The "mean lumen output" of a lamp over a certain operating interval is the total lumen-hours delivered, divided by the number of hours in the interval. The mean lumen output of lamps for rated life is useful in indicating the average lamp performance to be expected during the life of the lamp.

What is the lumen output of a 400-watt mercury lamp burning in the horizontal position with and without a magnet expressed as a per cent of the light output for vertical burning?

Depending on lamp design and the ballast employed, the horizontal lumen output will be 93 to 97 per cent of the vertical base-up lumen output when operated on the same ballast and without a magnet. When a magnet is used the horizontal lumens will be 95 to 98½ per cent of the vertical lumens. Actual values may be ascertained by consulting with the lamp manufacturer.

In a recent installation an account purchased 40-watt uncompensated ballasts. Can I recommend group replacement of lamps for this account?

ASA ballast specifications require preheating current normally not obtainable without the use of a compensator. The lack of compensators in this installation suggests possible other ballast defects which also would affect life and make prediction of lamp performance uncertain.

What is the approximate wattage dissipated as radiant heat from a 40-watt fluorescent lamp and a 150-watt incandescent lamp?

Approximately 22 and 137 watts will be radiated as infra-red and visible radiation from the 40-watt fluorescent and 150-watt incandescent lamps respectively.

Glow-switch type starters for preheat fluorescent lamps contain a small capacitor. What is its function?

This capacitor (usually about 0.006 microfarad) is connected across the switch contacts to aid in lamp starting and to aid in suppressing conducted radio interference.

See page 8-53, *I.E.S. Lighting Handbook*, Second Edition.

Would I experience loss of performance in using two 115-volt general service incandescent filament lamps in series on 230-volt industrial circuits to make use of existing wiring?

Two 115-volt lamps can be used in series as proposed, but it is not generally recommended because of increased overall maintenance cost.

Here and There with I.E.S. Members

Representatives from all Sections and Chapters in the Great Lakes Region get together to discuss plans on the forthcoming Conference.

Industrial lighting shop talk? Past and present chairmen of the I.E.S. Industrial Lighting Committee get together at a coffee break in the Technical Committee Forum. Left, J. R. Chambers, current chairman; at right, A. A. Brainerd, who previously guided this important committee activity.

Joint dinner meeting of Georgia Section and the Atlanta Residence Lighting Forum, at the Shrine Temple, Atlanta, January 18. See page 14A for details of the meeting.

Lighting and fog problems on New Jersey Turnpike is under study by the N. J. Turnpike Authority, under the direction of Ellis Paul, right. At a recent I.E.S. gathering Mr. Paul here discusses these problems with Charlie Rex (left), also of the I.E.S. Street and Highway Lighting Committee.

Photo: Berlon Cooper, *Electrical Construction and Maintenance*

Panel of school lighting experts which took part in the School Lighting Symposium sponsored by the New York Section, I.E.S., on January 28 at the Architectural League, are: l. to r., H. E. D'Andrade, C. L. Crouch, Stanley McCandless, B. F. Greene, Carl Allen, John Neidhart and Douglass Hashel.

T E L E C A S T
LIGHTING NEWS OF CURRENT INTEREST

Summary of Action Taken at February Council Meeting

The Society's largest Council meeting was held February 11, at the Lexington Hotel in New York. In the absence of President A. Homer Manwaring, Duncan Jones, Vice-President, presided. Among the 34 Council members and others attending were four Past-Presidents of the Society, Messrs. Lee Tayler, E. M. Strong, A. F. Wakefield, and S. G. Hibben. Attending the meeting were: Past-Presidents S. G. Hibben and E. M. Strong; Vice-Presidents D. M. Jones and R. F. Hartenstein; General Secretary M. N. Waterman; Treasurer K. M. Reid; Directors G. W. Beals, J. S. Schuchert, C. C. Shotwell, B. J. Jensen proxy for W. A. Stannard; J. F. Whitehead, Jr., F. C. Winkler; Regional Vice-Presidents: C. J. Berry; S. H. Hazleton, Jr. proxy for G. B. Buck, II, M. B. Hastings, L. A. Hobbs, W. J. Lind, R. L. Biesele, Jr. proxy for M. J. Myers, Jr., G. E. Park, J. R. Chambers proxy for C. B. Pederson, G. J. Taylor, L. C. Twichell; Executive Secretary A. D. Hinckley; Technical Director C. L. Crouch; Editor Ruby Redford; Willard Allphin, W. W. Booth, E. H. Church, C. C. Keller, C. N. Laupp, C. W. McCormick, A. C. Sangster, L. E. Tayler and A. F. Wakefield.

Reports and recommendations on studies referred to them were made by Finance Committee Chairman Warren Booth, and General Secretary Marshall Waterman and a statement of the Society's financial status was studied and discussed.

Conference Plans

Charles Laupp of the Technical Conference Committee outlined the tentative program set up for the Atlantic City Conference. An interesting arrangement was indicated whereby definite spaces were left open to committee meetings, so that such meetings next fall will not overlap with technical sessions. Organized time for this important phase of the conference met with marked approval of those present. The program as outlined provided some eleven sessions, three of them parallel.

New Chapter in Shreveport

On petition, presented by R. L. Biesele, Jr., from a group of active members in Shreveport, La., Council considered, and approved a Charter for a new I.E.S. Chapter there. Name of the new group, which qualified in all respects for a Charter, will be the Ark-La-Tex Chapter of I.E.S.

In a further report on Regional Activities, R. F. Hartenstein indicated that member groups are especially active in Idaho and Richmond, Va. He also noted that the Utah Chapter is approaching section status.

Other reports on regional affairs included recommendations for Chairmen certificates, regional conference programs, and the resignation of C. B. Pederson, Midwestern Regional V-P which was accepted with regret. Successor to Mr. Pederson, who is leaving the country on a new phase of his job, will be made by Council at a later date.

Membership

A report of the Board of Examiners recommended for approval 16 elections to Member grade, and reported the election of 81 Associate Members and 8 Students. Current membership, including all changes, is shown as follows:

September 30, 1953		February 11, 1954
7795	Total Membership	8048
32	Members Emeritus	32*
70	Fellows	68
1870	Members	1923
5579	Associate Members	5752
244	Student Members	273

*Includes 12 Fellows.

Sustaining Members

On recommendation of C. C. Shotwell, Sustaining Membership Chairman, Council approved the following new Sustaining Members:

Canadian General Electric Co., Ltd.
Lamp Division
165 Dufferin Street
Toronto, Ont., Canada.
Official Representative: E. H. Lindsay

Jewell Electric Products, Inc.
266 Glenwood Avenue
Bloomfield, N. J.
Official Representative: Joseph G. Wares

Litecraft Manufacturing Corp.
8 East 36th Street
New York 16, N. Y
Official Representative: Ben Roisman

Luxor Lighting Products Inc.
Empire State Building
New York, N. Y.
Official Representative: Sergei Marketan

Meade Electric Company, Inc.
5401-15 W. Harrison Street
Chicago 44, Illinois.
Official Representative: Henry E. Burkhardt

M.M.I.L.J.

Lee Tayler, Chairman of the Lighting Service Committee, reported on the progress to date of some 45 local contests for My Most Interesting Lighting Job. Keen interest was indicated in this year's contest by all groups reporting.

Officer Nominations

Mr. Tayler, who also served as Chairman for the Board of Nominations reported the following slate for the coming elections:

President—Duncan M. Jones, Curtis Lighting Inc., Montreal, Ont.

Vice-President—Marshall Waterman, Westinghouse Electric Corp., Bloomfield, N. J.

General Secretary—Kirk M. Reid, General Electric Co., Cleveland, Ohio.

Treasurer—George J. Taylor, Day-Brite Lighting Inc., New York, N. Y.

Directors—L. C. Twichell, Rochester Gas & Electric Corp., Rochester, N. Y.
J. S. Walsh, Pacific Gas & Electric Company, San Francisco, Calif.

The committee offered the recommendation that the six Directors on Council be assigned as a committee to study advance planning for the Society's operation.

Publications Program

J. S. Schuchert, Publications Committee Chairman, reported in detail, organizations and projects undertaken by the committee this year. Of special significance to the program was the appointment of some 30 (so far) Section and Chapter Papers Reporters and 15 (also so far) Sales Reporters, to serve with the Committee locally. With the eventual full-scale operation of these assignments in all Sections and Chapters, the Committee expects to greatly expand and improve the Society's publications.

Light's Diamond Jubilee

S. G. Hibben, Chairman of the I.E.S. Task Committee for Light's Diamond

Jubilee, gave an illustrated report on activities to date in the celebration this year of Light's Diamond Jubilee.

PROCEDURES AND POLICIES

This committee, which studies procedures and policies of Society operation for recommendation to Council, presented a report, given by Professor E. M. Strong, Chairman. Recommendations approved included a policy whereby a popularized report of I.E.S. activities would be sent to all members.

RESEARCH REPORT

The annual report of the I.E.S. Research Fund was presented to Council by A. F. Wakefield, Chairman. Included in Mr. Wakefield's presentation was a popular description of each project now underway. An illustrated version of this, in lay language, is being considered for publication soon in IE.

I.E.S. AT C.I.E. CONGRESS

The invitation received from the Commission Internationale d'Eclairage for a paper by I.E.S. Technical Director C. L. Crouch at the next Congress, was approved by Council, following appropriate committee study. Subject to C.I.E. approval of the paper, Mr. Crouch will attend the C.I.E. Congress in Switzerland in June 1955.

Theatrical Lighting Demonstration Huge Success in San Francisco

Five hundred and fifty I.E.S. members and invited guests attended a demonstration of theatrical lighting, sponsored jointly by the Northern California Section and the San Jose Chapter, January 21, in San Francisco.

This unusual event had its genesis when James Barnes, Northern California Section Program Chairman, approached Arch Monson, head of Kliegl Lighting Co. of California and the C. J. Holzmueller Co., the West's oldest theatrical lighting firm, for a program for the January meeting. Mr. Monson, who handled the lighting of all pageants and other special events during California's three-year Gold Rush and Statehood Centennial Celebration, 1948-1950, offered to obtain the Marines Memorial Club theater for the evening and make a stage presentation. Under the general chairmanship of C. W. Macy, a large committee was formed and a special mailing of invitations was made to architects, decorators, display artists, school officials and others.

The program was conducted by Robert Graham, Holzmueller Co., and stressed the application of dramatic lighting to public buildings, churches, homes and gardens as well as to the theater.

A large amount of equipment was assembled for the evening, some even being brought from Los Angeles, and one dimmer being built for the occasion. Mr. Graham demonstrated the division of a stage into six areas with two floodlights focused from either side — one as insurance against burnout of the other — and said the trend is now toward triangular lighting by means of a third lamp for each area, mounted above and to the rear of the stage. With the aid of a model he showed how depth and perspective are obtained with light. Much use of color was made.

Photo: W. A. Cyr, *Electrical West*

DEMONSTRATION of how theatrical lighting may be applied to other uses, by Robert Graham, of the C. J. Holzmueller Co., San Francisco, was a highlight of a program, sponsored January 21, by the Northern California Section and the San Jose Chapter of I.E.S.

Requesting the Pleasure of Your Company

All I.E.S. members are cordially invited by Southern Regional V-P Glenn Park to attend the meeting of Council, April 10, at the Roosevelt Hotel, in New Orleans, following the two-day Southern Regional Conference there.

French I.E.S. Convention Scheduled for June

The annual convention of the Association Francaise des Eclairagistes will be held June 8-12 in Monaco. General subjects that will be covered at the conference are (1) Lighting and "Tourisme" which will discuss street lighting, automobile headlamps, lighting on trains and airplanes, park and garden lighting, the illumination of monuments, and lighting in hotels; (2) Quality of installations.

Lighting Competition Set For Electrical Contractors

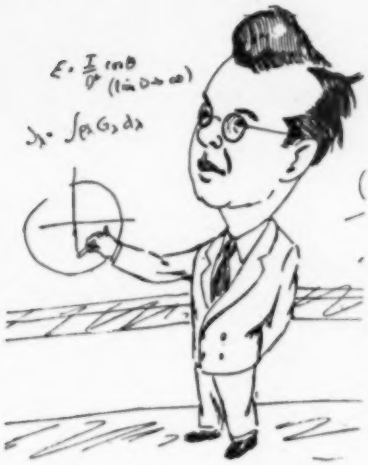
In conjunction with Light's Diamond Jubilee celebration this year, *Electrical Construction and Maintenance*, McGraw-Hill publication, is sponsoring a lighting competition for electrical contractors.

Eighteen cash awards, totalling $1,350, will be presented for the best lighting installations completed by electrical contractors on or between August 1, 1953 and December 1, 1954. Deadline for entries is midnight, December 1, 1954.

Appointed to the independent board of judges are: Thomas Smith Kelly, chairman, lighting consultant, Thomas Smith Kelly Lighting, Inc., New York City; Thomas F. Coghlan, illuminating engineer, Public Building Services, General Services Administration, Washington, D. C.; and C. L. Crouch, I.E.S. Technical Director.

Entries will be judged on sales effort, practical or aesthetic customer benefits, effective use of industry aids, lighting adequacy and technical design in engineering features, and artistic appearance.

The contest is designed by the magazine "to foster and encourage outstanding lighting installations by electrical contractors, and to stimulate industry interest and activity toward the further progress of electrical illumination."



OLD LUMEN PUSS

Professor D. M. Finch
as seen by his students
"At least the math is correct"

(Drawing submitted by Professor Finch; executed by Anonymous)

First, second and third awards, of $100, $75 and $50, respectively, will be given for each of six types of lighting installations: stores, schools and offices, industrial, residential, floodlighting, and miscellaneous (banks, museums, hospitals, churches, theaters, etc.).

Any individual who is either the owner or full-time employee of a regularly established electrical contracting firm may compete for an award.

National Relighting Program Moves Ahead

Generally favorable reactions greeted the National Lighting Bureau's Relighting Promotion Program, when it was presented to an all-industry Board of Advisors, at a meeting of the Executive Committee of that organization at the Hotel Roosevelt, New York City, in mid-January. This program has been in formation by a committee of the Industrial and Commercial Lighting Equipment of N.E.M.A., for the last year and a half.

The members of the 16-man Advisory Board of the National Lighting Bureau have been appointed by E.E.I., I.A.E.I., I.E.S., N.A.E.D., N.E.C.A. and the major lamp companies to help coordinate the activity. They bring to the program the benefits of the thinking of each of the major segments of the electrical industry. E. C. Huerkamp, of Westinghouse Electric Corp., Cleveland is Chairman of the Executive Committee.

Progress of the program, reported at the January meeting, indicated that technical and legal details of certification have been cleared; original manuscripts of the technical education course chapters — each prepared by a leading authority in the field — are being checked by members of the responsible subcommittee. At the same time, these chapters are being rewritten by the training agency retained for this operation. The same agency is preparing the sales training course, and its researchers, along with the

(Continued on page 13A)

LIGHTING CALENDAR

Society Events

April 8-9, 1954—Southern Regional Conference, Roosevelt Hotel, New Orleans, La.

April 10, 1954—Meeting of the I.E.S. Council, Roosevelt Hotel, New Orleans, La.

April 11-13, 1954 — Southwestern Regional Conference, Rice Hotel, Houston, Texas.

April 15-16, 1954—Inter-Mountain Regional Conference, Hotel Brown Palace, Denver, Colo.

April 19-20, 1954—South Pacific Coast Regional Conference, Museum of Art, San Francisco, Calif.

April 22-23, 1954 — Pacific Northwest Regional Conference, Benjamin Franklin Hotel, Seattle, Wash.

April 28-30, 1954—Canadian Regional Conference, King Edward Hotel, Toronto, Ont.

May 3-4, 1954 — Great Lakes Regional Conference, Sheraton-Cadillac Hotel, Detroit, Mich.

May 18, 1954—Northeastern Regional Conference, Hotel Bond, Hartford, Conn.

June 10, 1954—Meeting of the I.E.S. Council, New York, N. Y.

June 17-19, 1954—Midwestern Regional Conference, Jefferson Hotel, St. Louis, Mo.

September 13-17, 1954—Illuminating Engineering Society, National Technical Conference, Chalfonte-Haddon Hall, Atlantic City, N. J.

Industry Events

March 8-11, 1954—National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

March 9-12, 1954 — American Management Association. General Management Conference, Fairmount Hotel, San Francisco, Calif.

March 10-12, 1954 — American Society of Mechanical Engineers, International Meeting, Del Prado Hotel, Mexico, D. F.

March 18-19, 1954 — American Trade Association Executives, Spring Meeting, Sheraton-Carlton Hotel, Washington, D. C.

April 1-3, 1954—Electrical Industry Show, Shrine Exposition Hall, Los Angeles, Calif.

April 5-8, 1954—Edison Electric Institute Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

May 3-7, 1954 — Society of Motion Picture and Television Engineers, Semi-Annual Convention, Hotel Statler, Washington, D. C.

May 13-14, 1954 — Public Utilities Advertising Association, National Convention, Hotel Statler, Boston, Mass.

May 17-20, 1954 — Basic Materials Exposition, International Amphitheatre, Chicago, Ill.

May 19-21, 1954 — Pacific Coast Electrical Association, Inc., Hotel Del Coronado, Coronado, Calif.

June 6-11, 1954 — National Association of Electrical Distributors, 46th Annual Convention, Atlantic City, N. J.

June 7, 1954, Week of — Society of the Plastics Industry, Sixth National Exposition, Cleveland, Ohio.

June 20-24, 1954 — The American Society of Mechanical Engineers, Semi-Annual Meeting, William Penn Hotel, Pittsburgh, Pa.

June 21-25, 1954 — American Institute of Electrical Engineers, Summer General Meeting, Los Angeles, Calif.

September 8-10, 1954—The American Society of Mechanical Engineers, Fall Meeting, Schroeder Hotel, Milwaukee, Wis.

September 22-24, 1954—Canadian Electrical Manufacturers Association, General Brock Hotel, Niagara Falls, Ont., Canada.

September 29 - October 2, 1954 — International Association of Electrical Leagues, Bellevue Stratford Hotel, Philadelphia, Pa.

October 4-7, 1954 — National Association of Electrical Distributors, Pacific Zone Convention, Mark Hopkins Hotel, San Francisco, Calif.

October 11-15, 1954—American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

October 17-22, 1954—Society of Motion Picture and Television Engineers, Semi-annual Convention, Los Angeles Ambassador, Los Angeles, Calif.

October 18-22, 1954—42nd National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

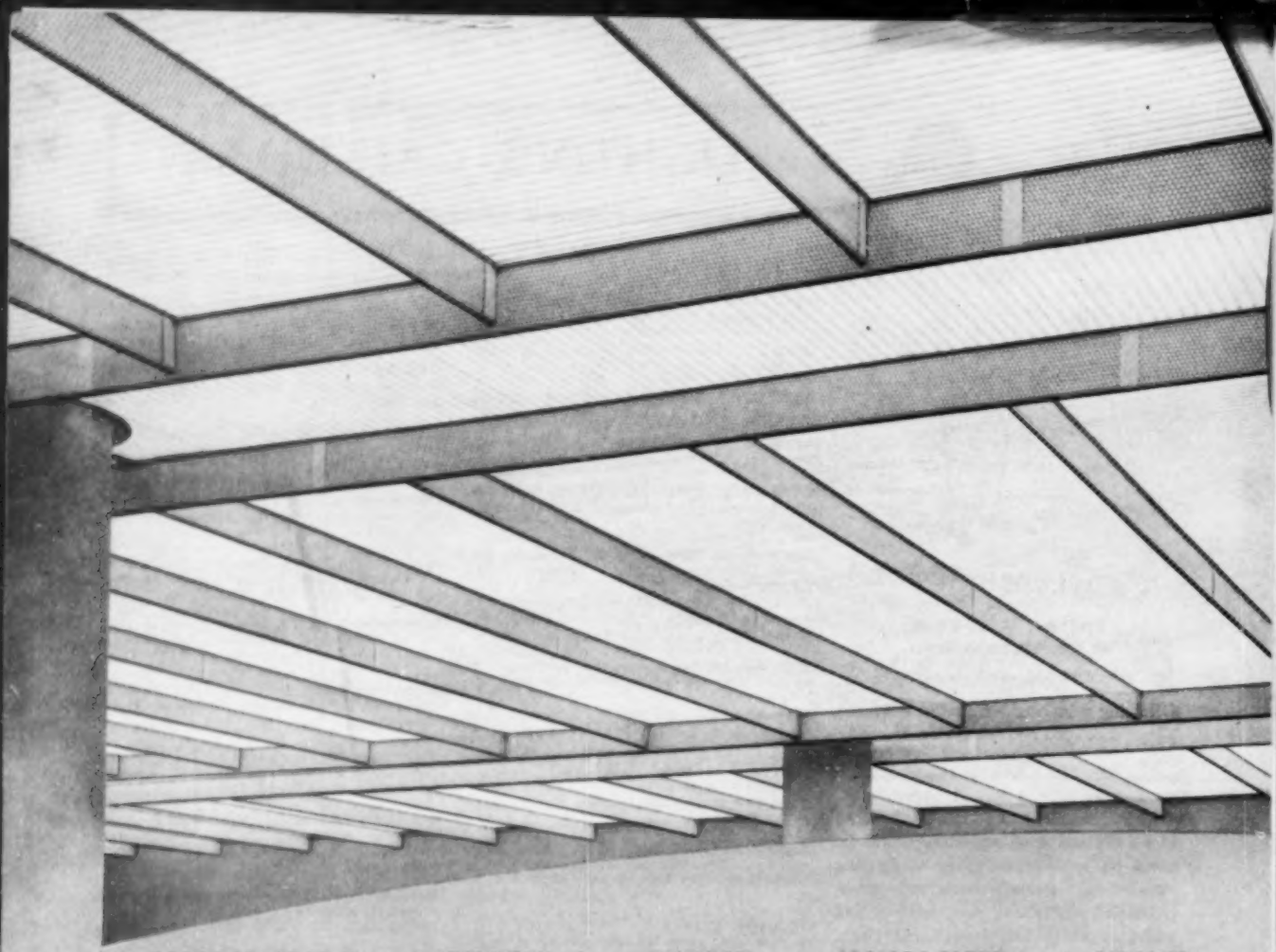
October 24-27, 1954 — Board of Governors, National Association of Electrical Distributors, Hershey Hotel, Hershey, Pa.

November 8-11, 1954 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

November 15-17, 1954 — 41st National Foreign Trade Convention, Waldorf-Astoria Hotel, New York, N. Y.

November 15-17, 1954 — American Standards Association, 5th National Conference on Standards and 36th Annual Meeting, Hotel Roosevelt, New York, N. Y.

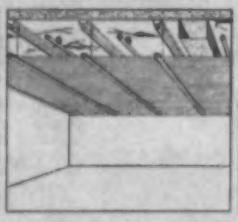
November 28 - December 3, 1954 — The American Society of Mechanical Engineers, Annual Meeting, Statler Hotel, New York, N. Y.



PROVIDES CORRECT ILLUMINATION

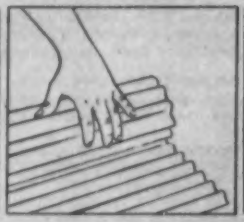
Acusti-Luminus Ceiling is both efficient and easy on the eyes. Foot-candles may be regulated by varying the number of fluorescent lights above Lumi-Plastic ceiling. The source of light is not perceptible—thus creating a "luminous environment" for minimum eye strain and maximum working efficiency.

MODERNIZES OLD CEILINGS



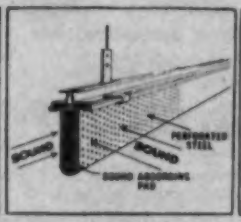
New lowered ceiling hides pipes, sprinklers, ducts, cracks. This gives ceiling clean, modern lines. Not only are these old eye-sores hidden, but the Acusti-Luminus Ceiling makes a readily accessible cover for the pipes, ducts, and valves. To get to any of these, the plastic is simply rolled up like a blind.

SAVES ON MAINTENANCE



Rolls easily for washing and relamping. And light is so evenly diffused up to 20% of lamps may burn out before dark spots are noticeable. Thus, *all* lamps may be replaced at once. While plastic is down, it can be washed and destaticized in a detergent or by a specially furnished machine for only 1¢ to 3¢ a sq. ft.

ABSORBS SOUND ECONOMICALLY



Acusti-Louvers absorb sound, also louver out the view of ceiling. Clip-on acoustical baffles can be added or subtracted as requirements in an area vary to meet any acoustical need. Their cost is far less. Lumi-Plastic is "transparent" to sound so that any existing acoustical material above it still functions.

SAVES ON INSTALLATION

TOP SLEEVE COUPLINGS
TRACK SLEEVE COUPLINGS
Easy to install. Track and couplings all slide together. No screws, nuts or bolts are used. A step-by-step installation drawing is sent with each job.

Installation is clean and simple. No special skill is required for simple and rapid assembly of these lightweight units. The product is self-spacing, rigid, and fool-proof. Complete shop drawings and instructions are included. Acusti-Luminus engineering staff is available in major cities for consultation.

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Acusti-luminus ceilings ...a Light for Indoors Actually Superior to Daylight!

ABOVE—*Partial view of Acusti-Luminus Ceiling at J. A. Folger & Co., Kansas City, Mo., makers of Folger's Coffee, shows how former shipping room was remodeled to make this modern, efficient accounting department.*

Architect: *Emmett M. Robison of Cooper, Robison and Carlson, Kansas City.*

Bring Modern Design well within the Budget

Now! Evenly diffused light... without shadow or glare! Streamline your remodeling jobs and "dreamline" your new ones—with beautiful, modern Acusti-Luminus Ceilings.

Light is uniformly diffused by the lightweight, unbreakable corrugated Lumi-Plastic—so there is no shadow or glare. The result is a source of low brightness—of any intensity.

A solid "ceiling of light"—this is the last word in the newest trend toward large sources of light—already 2800 installations in 36 states!

Excellent acoustical correction is also provided by noise-absorbing fins which may be hung at intervals below the plastic ceiling.

The cost is low—less than conventional ceilings with the same illumination and sound correction.

Quickly and easily installed—these lightweight units make possible sizeable savings in installation. Also, once installed, the ceiling is readily adaptable to future interior alterations such as new walls and partitions.

Your inquiry is invited on any installation you may have in mind—or simply write for more information.

LABELED BY UNDERWRITERS' LABORATORIES *Acusti-Luminus Ceilings are UL labeled for use under sprinkler systems—without any change in fire insurance rates. In event of fire, the plastic (which does not support combustion) softens and falls to the floor so sprinklers function normally.*

OVER 2800 INSTALLATIONS IN 36 STATES!

Below are a few of the many installations in factories, offices, drafting rooms, critical work areas, stores, banks, schools, libraries, and public buildings:

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Pacific Gas & Electric Co.
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Standard Oil Co.
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Western Electric Co., Inc.
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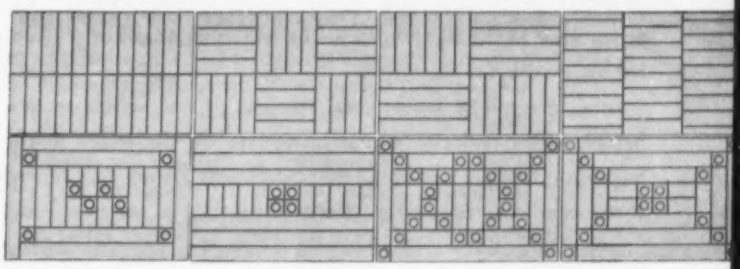
Simple construction allows the creation of varied designs. Modules of 3 feet make up the design. Spotlight sections may be inserted to emphasize displays and merchandise areas.



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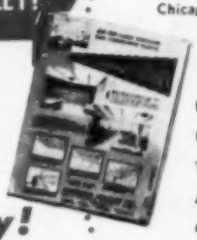

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IF YOU SPECIFY OR BUY FLUORESCENT FIXTURES:

Here is why General Electric believes you should insist on series ballasts for 96T12 lamps

Several years ago, our engineers studied the merits of the series-type ballast circuit for operating the 96T12 lamp at 425 ma. It showed real possibilities for economy, both in ballast cost and size. With concentrated efforts, a series ballast design for this lamp was perfected. Then for the first time, a series-type ballast circuit meeting all lamp requirements and giving full rated lamp life was made available to you.

Actually, there was nothing basically new about the series-type ballast. As early as 1940, our engineers had studied such a circuit. As new lamps were made available over the years, the series ballast was investigated time and again. However, prior to the 96T12 lamp, the potential savings of the series ballast circuit had been discarded because no way had been found to meet lamp operating requirements.

During those years the lead-lag ballasting circuit was widely used for the various types of lamps then available. Naturally, this type of ballast gained wide acceptance in the lighting industry as the standard of ballast quality.

After the 96T12 lamp was introduced, a series ballast was developed which proved to be the best ballasting tool for this important new lamp. However, there was real hesitancy about accepting a series ballast for the 96T12 because in the past, a lead-lag ballast had been found superior for other lamps.

We felt compelled to face this challenge and advocate the series ballast for the 96T12 lamp because, everything considered, we believe it is the best ballasting tool for that lamp—giving equivalent performance in accordance with lamp specifications and offering a very substantial saving in cost and size.

The results are now known throughout the lighting industry. Millions of series ballasts for operation of 96T12 lamps at 425 ma have been furnished to the industry in the last three years by ballast manufacturers. And because series ballasts for this lamp are inherently 20% less costly—even more millions of dollars in basic ballasting cost have been saved for fluorescent lighting users.

It will continue to be our policy to use our engineering know-how and detailed knowledge of lamp requirements to produce and promote the sale of the very best ballast or selection of ballasts for every type of lamp. Whether lead-lag, series, or trigger-start, in our sincere best judgment, they will always represent the best ballast design to meet lamp and industry requirements. General Electric Company, Schenectady 5, New York. 401-4

You can put your confidence in—

GENERAL ELECTRIC

(Continued from page 9A)

Director of the Bureau, have visited contractors and utility commercial managers and their staffs in some twelve cities, spread from Hartford to Baltimore to Pittsburgh to Milwaukee.

The time-table, as set up at present, calls for presentation of details of the program to industry groups in potential pilot cities in April. The presentations will be buttressed with portions of the program in printed form, supplemented by the rest of the material in draft or dummy form.

Pilot runs will be made in one large, one medium and one small city. Following their selection, the industry groups in these cities will be aided in the organizing of their respective local programs and the setting-up of their local lighting bureau. Each pilot city will be ready to start its training classes, certification and promotion in September.

Forty-Five Sections and Chapters Hold M.M.I.L.J. Contests

An interim report to Council last month of the Lighting Service Committee, guiding father of the My Most Interesting Lighting Job contests, showed 45 local contests had been organized this year. By this time many of these have already been held. Several Regions are booked solid, notably the Midwest Region which has a contest in every one of its Sections and Chapters, each directed by a chairman.

An interesting sidelight on the interest shown in this contest is a sub-contest for My Most Interesting Lighting Job conducted by Silvray Lighting, Inc., amongst its own salesmen, winner to receive a special award and possible entry in the I.E.S. competition.

Diamond Jubilee Committee Issues Plan Book

Light's Diamond Jubilee Committee, the organization heading the nation-wide celebration this year of the 75th anniversary of Edison's incandescent lamp, has announced the issuance of its two basic publications, "Light's Diamond Jubilee Plan Book" and "Light's Diamond Jubilee Fact Book."

The Plan Book, containing 32 pages, details plans and suggestions for Jubilee activities by both utilities and manufacturers in this industry-wide celebration. It also lists the organizations participating in the Jubilee and the members of the Jubilee committees.

PROGRAM Committee Chairman George Evans, at blackboard, and committee members outline the technical sessions and social program of the Great Lakes Regional Conference.

Great Lakes Region — Two-Day Conference

TIME: May 3 and 4, 1954.
PLACE: Hotel Sheraton Cadillac, Detroit, Mich.
REGISTRATION: $14.00 Men; $12.00 Ladies
To John Dawson, Chairman of Registration
Detroit Edison Company

PROGRAM: See below.

MONDAY, MAY 3

8:30 - 9:45	Registration.
9:45 - 10:00	Opening Remarks—A. C. Sangster, General Chairman.
10:00 - 12:00	My Most Interesting Lighting Job—Earl Domoney, Chairman.
12:30 - 2:00	President's Luncheon.
2:00 - 3:00	New Trends in Mercury Lighting—Dana W. Rowten.
3:00 - 4:00	A New Technique of Lighting Education—P. E. Stephens.
4:00 - 5.00	Visual Comfort Index—R. L. Oetting.
EVENING	President's Reception and Dance.

TUESDAY, MAY 4

9:00 - 10:00	Performance of Rapid Start Fluorescent Lamps—A. C. Barr.
10:00 - 11:00	Improved Fluorescent Maintenance—T. C. Sargent.
11:00 - 12:00	A Review of 75 Years of Home Lighting—Mary Taepke.
2:00 - 3:30	Good Classroom Lighting Is Cheap—Kenneth Welch and H. G. Daverman, plus invited discussions.
3:30 - 4:30	Progress Report—M. N. Waterman, I.E.S. General Secretary.

SUMMARY:

Theory, 1 hour; Sources, 2 hours; Application, 3½ hours; Residential, 1 hour.

The Jubilee Fact Book, containing 92 pages, presents the most important developments of electricity in the past 75 years in a series of 21 articles, each dealing with one area of electrical progress. It is written in a simple style with technical discussions kept to a minimum.

The books have similar covers, being designed as companion pieces. The Plan Book has a blue cover with a gold and white design; the Fact Book has a white cover with a blue and gold design. They are available from Light's Diamond Jubilee Committee, Room 2650, Graybar Building, 420 Lexington Ave., New York 17, N. Y.

Street Lighting Session Feature of South Pacific Coast Regional

An important conference on street lighting will be held in San Francisco April 20, as a parallel session to the eighth annual regional conference of the South Pacific Coast Region of I.E.S. A demonstration of street lighting research problems at the University of California's field test laboratory at Richmond, California the same evening will be a second event of special interest to all who are concerned with traffic lighting problems.

South Pacific's regional conference opens Monday morning April 19 at the San Francisco Museum of Art, for a two-day program devoted particularly to lighting as an element in architecture and interior design. Joint sponsor with the I.E.S. Sections and Chapters of the region will be the Northern California Chapter of the American Institute of Architects.

The parallel session on street lighting April 20 will open at 9 a.m. at the Western Merchandise Mart, San Francisco. First speaker will be David M. Baldwin of Chicago, traffic engineer of the National Safety Council, speaking on "Lighting and Night Traffic Accidents." Victor Paulsen of the Yellow Cab Company, San Francisco, will follow, discussing "Street Lighting for the User."

Paul Schmidt, district lamp engineer of the General Electric Company at Oakland, will speak on "New Developments in Street Lighting Sources," exhibiting types of lamps newly available. A description and demonstration of the new Finch-Simmons Visibility Meter will be given by Professor Dan M. Finch of the University of California College of Engineering. The session will close with a talk on "New Developments in Street Lighting Equipment" by R. E. Madigan, Line Material Company, Milwaukee, Wisconsin.

Professor Finch will be host at the evening demonstration in Richmond, which will follow dinner at Spenger's Fish Grotto in Berkeley.

Chairman of the street lighting session will be W. P. "Teddy" Bear of Van Nuys, Member Emeritus of I.E.S. and for many years, chief illuminating engineer, Pacific Gas and Electric Company.

Georgia Section Meets with Atlanta Residence Lighting Forum

Some 150 persons attended the joint dinner meeting of the Georgia Section, I.E.S. and the Atlanta Residence Lighting Forum for their January meeting. Presiding at the session, which was held at Shrine Temple, Atlanta, was the Section chairman, J. E. Sweatte, Georgia Power Co. J. D. Poage, Program Chairman, presented the guest speaker, James A. Meacham, Industrial Sales Engineer, Sherwin-Williams Co., well-known color consultant. Mr. Meacham spoke on "Color in Relation to Lighting" — the extent to which each affects the other, and the importance of brightness ratios as a factor in glare and illumination.

SPEAKERS at the joint meeting of the Georgia Section and the Atlanta Residence Lighting Forum were, l. to r.: James A. Meacham, Industrial Sales Engineer, Sherwin-Williams Co., guest speaker; John E. Sweatte, Section Chairman; J. D. Poage, Chairman of the Section's Program Committee.

Architectural Design Competition To Be Held in U. of California

The first student competition in architectural lighting design to be sponsored by the Northern California Section, I.E.S., will take place this spring in the College of Architecture of the University of California. The competition is open to senior and graduate students, with the problem to be announced. Awards will be made at the May meeting of the Section.

Lloyd Gartner, A.I.A., well-known San Francisco architect who also is an active member of the I.E.S. section, is chairman of the competition, his committee including Robert Dummel, Charles Long and Lyle Patton. Acting for the University are Dean William W. Wurster and Professors Vernon De Mars and Michael Goodman of the College of Architecture.

The first prize will be $100, second $50 and third $25, plus suitable certificates of award. For the next three places, certificates and one-year student memberships in I.E.S. will be awarded.

The *I.E.S. Lighting Handbook* and published I.E.S. Recommended Practices will be the basis of all lighting calculations and layouts. The competition rules require that minimum illumination levels

(Continued on page 17A)

South Pacific Coast Conference Program

TIME: April 19-20, 1954.
PLACE: Museum of Art, San Francisco
PROGRAM: See below.

MONDAY, APRIL 19

Lighting As An Art Form—Dr. Grace McCann Morley, Director of the San Francisco Art Museum.
Inspection—Of five-week exhibition of interior design, decorated by W. & J. Sloane and lighted by local I.E.S. committee.
Application of Incandescent Lamps—Alston Rodgers.
Application of Fluorescent Lamps—Marshall Waterman.
Light's Diamond Jubilee—S. G. Hibben.
Color Systems and Their Use—Walter Granville.
Light and Color in the Store—D. P. Caverly.
Evening—Dinner Dance at Mark Hopkins Hotel.

TUESDAY, APRIL 20

Light and Color in the Home—E. W. Commery.
Functional Portable Lamps and Fixtures in the Home—Jack Blitzer.
Architecture and Engineering in Lighting Design—A. H. Manwaring, I.E.S. President.
Designing the Shopping Center—Victor Gruen.
Seeing and Selling with Display Lighting—Kenneth C. Welch.
Parallel Session on Street Lighting—Western Merchandise Mart, San Francisco.

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IN A LUMINAIRE OF SUCH RADIANT *Beauty*

GARCY *Starliner*

OVER 80% EFFICIENCY • 30° x 40° Shielding
. . . yet only 4½" Deep

Slim, trim and functional in appearance, the Garcy Starliner lends itself beautifully to contemporary styling. When surface mounted, its shallow contour economically simulates built-in lighting. Yet within its compact design, this luminaire embodies every wanted feature. Side panels of Corning's Alba-lite glass are attractively framed in protective metal rails . . . promote efficient light distribution while contributing to proper brightness control. Garcy's louver design provides 30° x 40° shielding. The Starliner is superbly made . . . note the round edges on end plates and side rails. Economically installed, easily maintained. Available as two-lamp or four-lamp units in 4 ft. or 8 ft. lengths for standard fluorescent, rapid start or slimline lamps. Write for Bulletin L-134.

FAST, LOW-COST INSTALLATION
with Garcy Sliding Clamp Hangers for easy alignment, both vertically and horizontally. Adjustable in height by simply turning stem.

ECONOMICAL MAINTENANCE
Single louver shield permits relamping two 8 ft. fixtures from one ladder position.

STURDY CONSTRUCTION
V-shaped backbone securely holds louver cross-fins under spring tension . . . prevents looseness, rattle or "sing."

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I.E.S. Regional Conferences, 1954

Southern	Roosevelt Hotel New Orleans	April 8-9
Southwestern	Rice Hotel Houston	April 11-13
Inter-Mountain	Hotel Brown Palace Denver	April 15-16
South Pacific Coast	Museum of Art San Francisco	April 19-20
Pacific Northwest	Benjamin Franklin Hotel Seattle	April 22-23
Canadian	King Edward Hotel Toronto	April 28-30
Great Lakes	Sheraton-Cadillac Hotel Detroit	May 3-4
Northeastern	Hotel Bond Hartford	May 18
Midwestern	Jefferson Hotel St. Louis	June 17-19

(Continued from page 14A)

be consistent with the best current practices for the visual tasks to be performed in both general and specific areas. A brightness balance must be maintained which will accomplish specified objectives such as sales, visual efficiency, comfort and atmosphere. A third requirement is that the lighting system be integrated as to type, form and scale with the architectural and decorative design of the room.

In connection with the competition, four lectures will be delivered by members of the Northern California Section to students registered in the College of Architecture.

Food Store Lighting Clinic Latest in Chicago Series

A full-day clinic on lighting of retail groceries, bakeries, meat markets and related food services was held February 16, sponsored by the I.E.S. Chicago Section and the Chicago Lighting Institute in cooperation with the following groups:

Associated Food Retailers of Greater Chicago
Associated Retail Bakers of Greater Chicago
Independent Grocers Alliance
Progressive Food Stores, Inc.

The clinic, which was held at the Institute's headquarters, consisted of a morning and an afternoon session with this program:

Welcome and Objectives of the Clinic—Charles A. Brommann, Associated Food Retailers.
Major Factors in Profitable Food Store Operation—Henry Longenbaker, Independent Grocers Alliance.
The What and Why in Lighting Sales Tools—Carl F. Jensen, Westinghouse Electric Corp.
New Approaches in Store Front and Parking Lot Lighting—S. H. Eaton, Sylvania Electric Products Inc.
Light on Food Merchandising Problems—Robert Dorsey, General Electric Co.
More Light for Your Money—W. F. Carson, Public Service Co.
Trends in Food Store Lighting—Dan Dunne, Lighting Products, Inc.

Ralph R. Lusk, Commonwealth Edison Co., was Chairman for the conference, and Eugene Day, Editor, *Chicago Retail Baker*, presided over the afternoon session.

SOME of the many challenging problems in the field of illuminating engineering are explained by R. F. Hartenstein to student Leonard Frick, while being televised at WNBK, Cleveland.

Cleveland Section TV Show Boosts Illuminating Engineering

A half-hour television program, entitled "Lighting for Seeing," was presented to the Cleveland TV audience on WNBK, Sunday, January 31, by members of the Cleveland Section, I.E.S. The program was one of a series in "Adventures in Engineering and Science" being sponsored each week by the Cleveland Technical Societies Council and its forty member societies in cooperation with WNBK. The series is designed as vocational guidance for high school students who are thinking about a career in the engineering profession.

(Continued on page 19A)

PARTICIPANTS in the Cleveland Section TV Program are, l. to r.: H. G. Schiller, the Section's TV Chairman; F. C. Winkler, I.E.S. Director; R. F. Hartenstein, Vice-President of the Society; Leonard Frick, 10th grade student; and I.E.S. members, E. A. Linsday, W. F. Graff, and R. M. Smart.

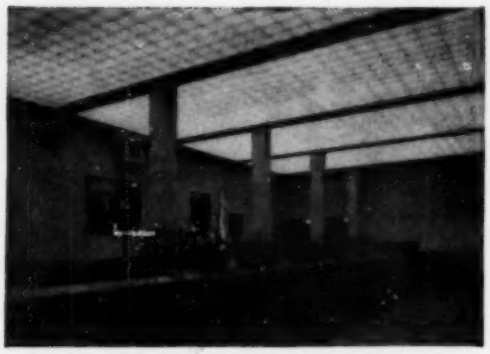
WILSON

"LUVE-TILE"

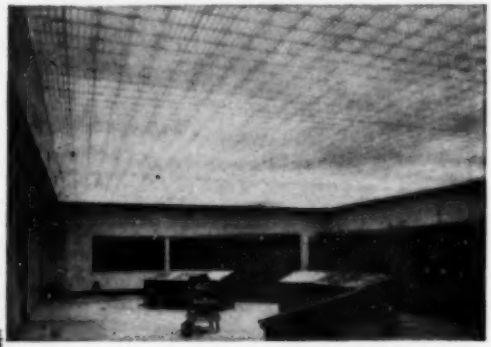
This latest development in modern interior lighting is a boon to contractors because . . .

- It is extremely simple to calculate the amount required for the installation.
- There are only four basic elements to use! A modular 12" square of rigidly molded polystyrene louvre, a clip, a hanger and a strap.
- There are no complicated T-bars necessary to support "Luve-Tile".
- "Luve-Tile" always aligns perfectly and pleases customers with its symmetry.
- "Luve-Tile" is scientifically designed and is correct from an efficiency and brightness viewpoint.
- When the installation is complete, it is very simple to maintain—an important factor in customer approval.

For complete information on "Luve-Tile" write for Catalog, Section #8.

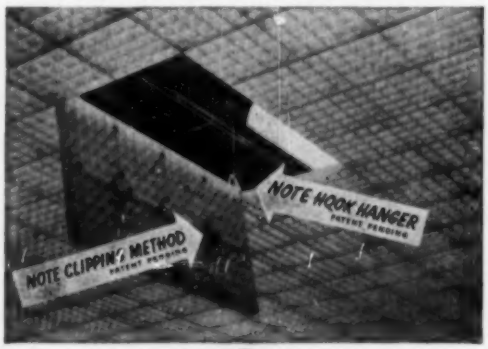


● Illustration shows a modern bank installation, where "Luve-Tile" helped to achieve an air of efficiency.



● In this power control room, "Luve-Tile" has successfully cut down glare and eyestrain.

● "Luve-Tile" was a major factor in achieving the modern appearance of this retail store.



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ANOTHER WILSON FIRST

World's Largest Lamp Marks Edison's Birthday

Observances of Thomas A. Edison's 107th birthday were held throughout the country on February 11. One of the more spectacular ceremonies was the public showing in New York City of the world's largest artificial light source. This was a 75,000-watt incandescent lamp which was turned on officially for the first time on February 11 during ceremonies in Rockefeller Plaza, just overlooking the skating rink. It will be displayed and lighted throughout the year at Light's Diamond Jubilee celebrations, and at conventions, shows and fairs, in all sections of the country.

The lamp produces 2,400,000 lumens; the filament alone weighs 2.7 pounds. At 75,000 watts it is half again as large as the previous largest, a 50,000-watt lamp developed in 1929 for the observance of Light's Golden Jubilee.

ATTENDANCE of 32 students from three universities ensured the success of the Student Seminar sponsored by the Michigan Section of I.E.S., January 14.

Fifty Million Americans Now Buy Electricity

Customers of electricity in the United States passed the fifty-million mark January 28, it was announced by Charles E. Wilson, chairman of the Sponsoring Committee for Light's Diamond Jubilee. For the first time, electric service is being simultaneously received by 50,000,000 customers throughout the country. This milestone for the electric industry was calculated by the Edison Electric Institute, on the basis of continuing statistics received from the industry throughout the country.

According to E.E.I. estimates, the 50,000,000th customer started to receive service at some time between 1:00 p.m. and 2:00 p.m. E.S.T. on January 28. Since some 600 new customers throughout the country were connected during that hour, it will never be known exactly who the 50,000,000 customer was.

A near-record of 55 enrolled in the Fundamentals of Illumination course in the Pittsburgh Section's Training program. Topics of the eight weekly two-hour sessions were presented in February IE, page 7a. The program is under the direction of H. S. Orton, Chairman of the Section's Education Committee.

Student Seminar in Illumination Sponsored by Michigan Section

A student seminar, principally for students interested in illumination from the University of Michigan, University of Detroit and Wayne University, was sponsored January 14 by the Michigan Section of I.E.S. These educational institutions are represented on the Educational Student Membership Committee by Professors W. A. Hedrich, R. W. Ahlquist and E. L. Fairchild, respectively.

Three students presented papers on the best solution of a problem on relighting a haberdashery store. These were David G. Boice, University of Michigan; Z. V. Rekasius, Wayne University; and Charles Schemeck, University of Detroit.

Guest speaker was Miss Mary Taepke, Detroit Edison Co., who presented an illustrated talk on Residence Lighting to Fit Structural Elements in the Contemporary Home.

The program was concluded by an inspection trip to the Daylighting Laboratory at the University of Michigan.

The attendance of 39 included 32 students.

Luncheon Honors Edison's Birthday

The Phillipsburg, N. J., Rotary Club entered into the spirit of Light's Diamond Jubilee, by holding a luncheon meeting, February 10 in honor of Thomas A. Edison. I.E.S. member Halsey E. Dickson was the guest speaker with the topic "Light for Living."

(*Continued on page* 20A)

C.L.I. Awards Citation To F. D. Wyatt

Recipient of the Chicago Lighting Institute Citation for 1953 is Francis D. Wyatt, Electrical Engineer with the Chicago Park District. The award was made by G. K. Hardacre, President of the Institute, at the annual President's luncheon held January 19 in the auditorium at the Institute.

This citation is awarded for the meritorious achievement in the advancement of the science and art of illumination, or for the application of good lighting engineering principles in the area served by the Chicago Lighting Institute. Mr. Wyatt, who is in charge of design, construction and operation of all electrical equipment used by the park system, has made outstanding lighting contributions to the Chicago area, receiving this award for his accomplishments in bringing the lighting of Chicago's boulevard system up to or better than that recommended by I.E.S. The system comprises 205 miles of boulevards, including the 21-mile outer drive extending from the Indiana line north to Evanston.

CITATION is awarded to F. D. Wyatt by Chicago Lighting Institute President G. K. Hardacre. Left to right: Paul F. Kauffman, Chairman, Chicago Lighting Institute Promotion Committee; Daniel Flaherty, Assistant Superintendent, Chicago Park District; Institute President Hardacre; F. D. Wyatt; R. J. Diefenthaler, Chairman, Institute Citation Committee and Carl W. Zersen, C.L.I. Managing Director.

ABOUT PEOPLE

Clarence B. Pederson, appointed by Council to fill the unexpired term of **L. B. Paist,** as Midwestern Regional V-P, has, himself, been forced to tender his resignation, due to greater and more varied business duties. Mr. Pederson has accepted a position in the Bell Telephone System of considerable importance to the government, in which capacity he will be traveling outside the country.

Members of the American Society of Heating and Ventilating Engineers, at their 60th Annual Meeting in Houston, Texas, January 25-27, elected **Louis N. Hunter** as president for the year 1954. Mr. Hunter is vice-president in charge of research with the National Radiator Co.

Sola Electric Co., Chicago, announces the opening of a branch office for specialty transformer sales in Los Angeles, with **Richard S. Smith** as District Sales Engineer.

The I.E.S. representatives to the Board of Advisors of the N.E.M.A. National Relighting Program are: **J. S. Schuchert,** Duquesne Light Co.; **J. B. Browder,** Georgia Power Co.; and **C. C. Shotwell,** Philadelphia Electric Co.

The appointment of **J. C. Sullivan** as Executive Vice-President of Pittsburgh Reflector Co. has been announced by H. C. Zinsmeister, President of the firm. Mr. Sullivan has been with the company for the past 28 years, and up to his present appointment served as Treasurer. In his new capacity, Mr. Sullivan will be in charge of general operations and the administration of the Sales Department. He will coordinate sales for the full line of the company's commercial and industrial fluorescent and incandescent lighting equipment.

Charles Knight has been appointed by the School of Education, Stanford University, as the recipient of a $400 gift of The F. W. Wakefield Brass Co., for an assistantship in connection with the Coordinated Classroom School Planning Laboratory at Stanford.

Nomination of **A. C. Monteith,** Vice-President in charge of Engineering, Westinghouse Electric Corp., Pittsburgh, as 1954-1955 President of the American Institute of Electrical Engineers, has been announced by H. H. Henline, Secretary. The announcement followed a meeting of the Institute nominating committee during the society's Winter General Meeting in the Hotel Statler, New York City.

The appointment of **William R. Sears** as San Francisco District Fixture Representative of Sylvania Electric Products, Inc., has been announced by that company.

Edmund J. Fitzmaurice, Jr., has been named sales engineering manager and advertising manager of the Electric Storage Battery Co.'s industrial division. Among other duties, Mr. Fitzmaurice will be in charge of sales of industrial storage batteries used in emergency lighting, and railway car lighting.

Wayne Trimpe has recently joined Hemphill and Co., district sales representatives for the Electro Silv-A-King Corp. in the Michigan cities of Lansing, Grand Rapids, Muskegon, Cadillac, Traverse City and Petoskey.

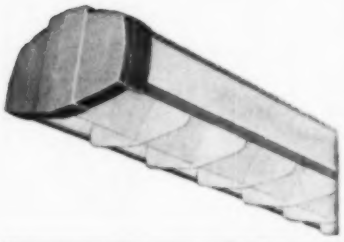
In recognition of his outstanding contributions to the advancement of heating, ventilating and air conditioning, **Walter L. Fleisher,** president of the Air and Refrigeration Corp., was the recipient of the F. Paul Anderson Medal for 1953, awarded by the American Society of Heating and Ventilating Engineers. Formal presentation of the award was made at the closing session of the society's annual meeting, in Houston, Texas, January 27.

Adam Heuslein has been appointed by the Illuminating Division of The Miller Co., Meriden, Conn., as field sales engineer for the Pennsylvania territory comprising Eastern Pennsylvania and Warren County, N. J. Mr. Heuslein has been connected with the company application and internal sales department. The company has also named as representative **Charles L. Woodyard** to the

(Continued on page 22A)

Supreme Market, Boston, Mass. Electrical Contractor: Massachusetts Electric Construction Company, Boston, Mass. Distributor: Graybar—Boston

Wakefield Grenadiers with Spots Do a Super Lighting Job in a Boston Super Market



The Grenadier is a finely engineered louvered unit with metal-framed plastic side panels. All metal parts finished in metallic satin. Shielding 35° normal to the lamp and 25° parallel. Stem, canopy or on-ceiling models—for pre-heat and Rapid Start bipin or Slimline lamps.

The owners of the Supreme Market in Boston were not willing to settle for ordinary lighting. Instead they demanded and got an over-all lighting installation which sets a new standard for super markets.

A total of 186 Wakefield two-lamp Grenadiers are installed in seven continuous rows, with 123 Grenadier Spots located in line at 4 and 8 foot intervals as the situation demanded. Lamps used are CW/de Luxe. Walls above counters are painted in light pastel colors. Ceiling is aluminum. Floor is light cream terrazzo.

Here are the ft-c. readings after 200 hours of burning:

General lighting between rows, less spotlights, 50 ft-c.

Bakery shadow boxes, small, 115 ft-c.

Bakery shadow boxes, large, 175 ft-c.

Vegetable counters, 200 ft-c.

Displays at ends of regular goods shelves on cross aisles, 300 ft-c. on high levels; 400 ft-c. 7 feet from the floor.

Dairy goods, cheese, etc., upper level, 250 ft-c.; lower level, 400 ft-c.

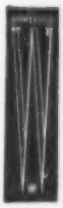
Ice Cream section, 300 ft-c.

Frozen meat, fish, etc., 100 ft-c.

Meat cutters, 200 ft-c.

For full information, write to The F. W. Wakefield Brass Company, Vermilion, Ohio. In Canada, Wakefield Lighting Limited, London, Ontario.

Wakefield Over-ALL Lighting



(*Continued from page* 20A)

Georgia-Alabama territory. Mr. Woodyard has offices at 161 Simpson St., N. W., Atlanta, Ga.

A. R. Parker, former lighting specialist and lighting manager of the General Electric Supply Co., in San Francisco, has been appointed as District Sales Manager of the Electro Silv-A-King Corp. His operations will include the northern half of California.

Crescent Electric Supply Co., **James and Richard Hirschfeld,** partners, has been named agent for Westinghouse lamps in the metropolitan San Francisco area.

OBITUARIES

Martin L. Sloan

Martin L. Sloan, former vice-president of the General Electric Company, died on January 27 at Los Altos, California, following a brief illness. He was 66. He had retired December 31, 1949, under the company's pension program, after nearly 40 years of service.

Mr. Sloan had been named vice-president of the company and general manager of the Lamp Division in 1945.

One of Mr. Sloan's best-known achievements involved the introduction of the sealed beam headlamp for automobiles 15 years ago. He not only acted as coordinator of the various G-E activities involved, such as engineering, manufacturing and sales, but also interested the various automobile manufacturers in the development, resulting in its adoption on most cars.

Mr. Sloan began his career with General Electric in 1910 as a commercial engineer for the National Lamp Works in Cleveland. In 1912, he was transferred to the Youngstown, Ohio Lamp Works, and a year later was advanced to the position of assistant manager. In 1914, he became assistant general manager of manufacturing at the Nela Park Lamp Division, and in 1921 was made manager. In 1927 he transferred to the administrative staff, being named assistant manager in 1931 and manager in 1942.

Mr. Sloan's guiding philosophy for the Lamp Division's operations was for teamwork and an intense application of technology for mass production.

Charles W. Cornbrooks, Supervising Electrical Engineer with the Maritime Administration of the U. S. Department of Commerce, passed away January 23 at the age of 52. Mr. Cornbrooks was Chairman of the I.E.S. Subcommittee on Marine Lighting, bringing to this activity his years of experience with specifying lighting equipment for all vessels under the Maritime Administration.

Elmer A. Holloway, Electrical Engineer with the Iowa Electric Light and Power Company at Cedar Rapids for the past 38 years, passed away January 21. Mr. Holloway, who joined I.E.S. as a full member in 1941, had served the Society as Secretary, Vice-Chairman and as Chairman of the Iowa Section.

NEW MEMBERS

At the meeting of the I.E.S. Council held in New York, N. Y. on February 11, the following were elected to membership. Names marked * are transfers from Associate Member grade.

ALABAMA CHAPTER

Member:
Johnson, L. E., Juneman Electric Co. Inc., Birmingham, Ala.

ALAMO CHAPTER

Associate Members:
Andrew, J. W., Central Power & Light Co., Corpus Christi, Texas.
Greenwell, B. J., Gillis & Greenwell Electric Co., San Antonio, Texas.
McDowell, H. D., Corpus Christi Hardware Co., Corpus Christi, Texas.

ARIZONA CHAPTER

Associate Member:
Blanton, J. E., Arizona Public Service Co., Globe, Ariz.

CENTRAL ILLINOIS CHAPTER

Member:
Leiter, K. S., Leiter Electric Co., Peoria, Ill.
Associate Members:
Bean, Irwin, Foster Electric Co., Peoria, Ill.
Venters, J. W., Kiefer Electric Supply Co., Peoria, Ill.
Weiman, M. R., Associated Engineers, Peoria, Ill.

CHICAGO SECTION

Associate Members:
Anthony, D. J., Allan Anthony Electric Corp., Forest Park, Ill.
Kempf, V. T., Joseph T. Ryerson & Son, Inc., Chicago, Ill.
Posey, T. H., Jr., Commonwealth Edison Co., Chicago, Ill.

CLEVELAND SECTION

Member:
*Meaker, O. P., General Electric Co., Cleveland, Ohio.

CONNECTICUT SECTION

Associate Members:
Holland, W. G., American Electric Supply Co., Hartford, Conn.
Schonbrun, J. B., Crown Light Co., Hartford, Conn.

CORNHUSKER CHAPTER

Associate Members:
Fifer, T. J., Westinghouse Electric Supply Co., Omaha, Nebr.
Murphy, J. R., Graybar Electric Co., Sioux City, Ia.
Nyreen, C. W., Nystrom Electric Co., Sioux City, Ia.
Shoop, J. D., Crescent Electric Supply Co., Sioux City, Ia.

EASTERN NEW YORK CHAPTER

Member:
Harney, J. M., Smith Electric Co. Inc., Cohoes, N. Y.
Associate Members:
Fitzpatrick, H. J., Graybar Electric Co., Albany, N. Y.
McGrane, E. W., Thomas & Betts Co., Elizabeth, N. J.
Newman, K. C., F. W. Newman & Son, Inc., Albany, N. Y.

EASTERN PENNSYLVANIA SECTION

Associate Member:
Beidler, J. D., 506 Las Vegas Drive, Temple, Pa.

FOREIGN NON-SECTION

Associate Member:
Restrepo, Fernando, Ramon Cvellar y Co. Ltda., CRA 71, No. 24-51, Bogota, Colombia.

HEART OF AMERICA SECTION

Members:
*Hedges, I. J., Miller Lighting and Fixture Co., Kansas City, Mo.
Kindell, B. F., Graybar Electric Co., Kansas City, Mo.
Associate Member:
Hegler, B. E., 203 N. Star, El Dorado, Kans.

INDIANA CHAPTER

Associate Members:
Peloquin, R. L., Westinghouse Electric Corp., Indianapolis, Ind.
Schneider, F. J., Sanborn Electric Co., Indianapolis, Ind.

INLAND EMPIRE CHAPTER

Member:
*Chapman, T. J., Line Material Co., Spokane, Wash.

IOWA SECTION

Associate Members:
Morrissey, J. A., Iowa-Illinois Gas & Electric Co., Moline, Ill.
Rosche, James, Iowa Electric Light & Power Co., Cedar Rapids, Iowa.
Widigen, L. J., Iowa-Illinois Gas & Electric Co., Davenport, Ia.

MARYLAND SECTION

Associate Member:
Weaver, H. L., The Baltimore Gas & Light Co., Baltimore, Md.

MICHIGAN SECTION

Members:
*Davis, C. W., City Engineers Office, D.P.W., Detroit, Mich.
*Weins, J. F., City Engineers Office, D.P.W., Detroit, Mich.
Associate Members:
Atwood, W. S., The Detroit Edison Co., Caro, Mich.
Bach, B. R., Detroit Edison Co., Detroit, Mich.
Bedtelyon, A. F., Consumers Power Co., Flint, Mich.
Capatina, L. I., Ford Motor Co., Dearborn, Mich.
Chambers, R. W., Detroit Edison Co., Detroit, Mich.
Kelley, R. H., Detroit Edison Co., Detroit, Mich.
Merik, Boris, Detroit Edison Co., Detroit, Mich.

(*continued on page* 28A)

CFI DAY-LINE®

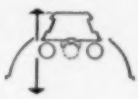
(COMFORT FOR INDUSTRY)

Easy to handle

Easy to install

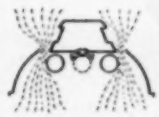
Contractor features include knockouts and fittings for pipe, chain, stem and messenger cable suspension; no-sag, no-bend one-piece reflector; simplified wiring.

AND LOOK AT THESE USER FEATURES THAT DELIVER EXTRA VALUE AND SATISFACTION TO YOUR BUYERS!



COMFORT FOR INDUSTRY. Die-embossed apertures in reflectors provide 10% up-lighting for improved visual comfort and freedom from irritation and nervous fatigue due to eye-strain.

ALL-WHITE PORCELAIN REFLECTORS. Outside as well as inside, entire one-piece reflector is finished in snow white porcelain enamel—providing maximum high reflection surface.



COOLER, CLEANER OPERATION. A gentle flow of air passes through the apertures reducing dirt and dust deposits. This "breathing" action keeps fixture cooler, cleaner and more efficient.

TURRET* SOCKETS. Sturdy, vibration-proof Turret sockets are standard equipment on all CFI DAY-LINEs—providing positive lamp seating and simple lamp installation or removal.

*® G. E. Co.

THE CFI DAY-LINE ON THE JOB. Note how uplighting cuts down uncomfortable brightness contrast. CFI DAY-LINE is available in 2 and 3 lamp (75W) open-end 8 ft. Slimline units; 2 and 3 lamp (40W) open- and closed-end 4 ft. RAPID-START Fluorescent units; 2 lamp (90W) open- and closed-end 5 ft. Fluorescent units with NO-BLINK starters.

Day-Brite Lighting, Inc., 5432 Bulwer Avenue, St. Louis 7, Missouri. In Canada: Amalgamated Electric Corp., Ltd., Toronto 6, Ontario.

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

421

CALL OR WRITE YOUR NEAREST DAY-BRITE REPRESENTATIVE

Set Sail

for 1954 I·E·S

NATIONAL TECHNICAL CONFERENCE

The Philadelphia Section of I.E.S. is arranging the biggest and best National Conference in all I.E.S. history. Here's just a general idea of what's in store for you —

Meetings
. . . crammed with valuable information

Social Events
. . . packed with fun

Sports
. . . bathing, boating, golf, fishing, races

Special Program
. . . for the ladies

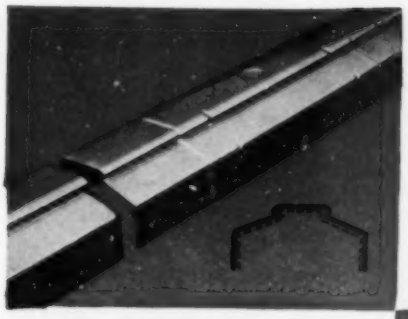
Spacious Hotel
. . . luxurious living

Diamond Jubilee
. . . electrical industry's celebration

Centennial
. . . celebrating Atlantic City's 100th birthday

Transportation
. . . convenient plane, railroad and bus routes

Vacation
. . . ideal spot to spend family vacations



LOCKED IN PERFECT ALIGNMENT

Uni-Race sections slide into a firm telescopic union with coupler forming a rigid channel that will not distort (even before screws are added) and assures perfect fixture alignment.

THE NEW

ortho-77

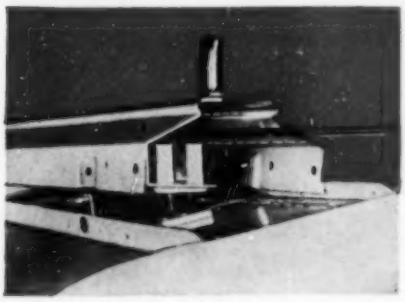
Reg. U. S. Pat. Off. Applied For

WITH UNI-RACE

Acclaimed by lighting experts everywhere as "ushering in a new era in fluorescent fixture design"; the spectacular new Ortho-77 by Gibson is an entirely new concept of fixture design. Incorporated for the first time on any fluorescent fixture are a multitude of features that simplify installation, provide position alignment and spacing and give greater fixture rigidity. Now without tools and in a matter of minutes you can change fixtures instead of ballasts . . . raise lighting levels from two to four light or vary the levels as conditions demand . . . install fixtures at intervals automatically spaced and fill in quickly and easily as needed. Contractors have claimed as much as 50% saving in installation time with the Ortho-77 which means that you, the user, can install this revolutionary fixture incorporating the new Uni-Race, "V" type integrated construction, simplified plug-in wiring and many other features at no greater cost than a conventional installation. See it at your jobber today or write for bulletin Ort-101 for complete information.

RIGID CHANNEL ANCHOR

Light in weight, readily accessible and easily mounted, the Uni-Race provides a rigid channel anchor for all Ortho-77 models. Being machined to exceptional tolerances, it automatically provides for exact fixture spacing.

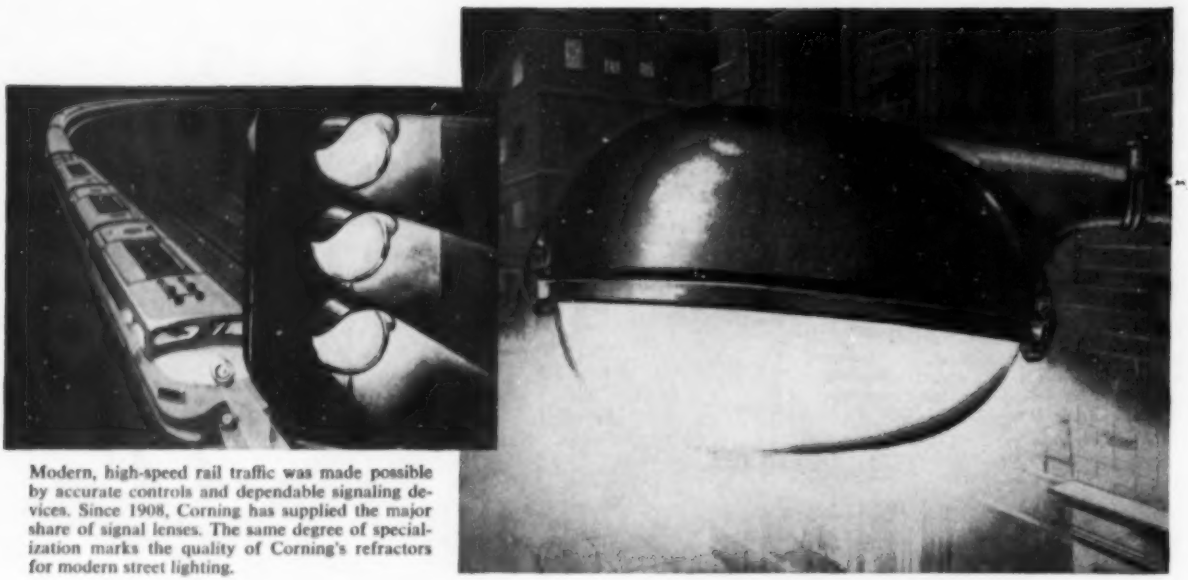


PLUG-IN SOCKET

Ortho-77 units are wired to a Plug-In Socket which makes contact with a receptacle in the Uni-Race when fixture is closed. Fixture becomes completely dead when open, and being wired in parallel circuits, does not disturb other fixtures when removed.

GIBSON Manufacturing Co.

1919 Piedmont Circle, N.E. Atlanta, Georgia



Modern, high-speed rail traffic was made possible by accurate controls and dependable signaling devices. Since 1908, Corning has supplied the major share of signal lenses. The same degree of specialization marks the quality of Corning's refractors for modern street lighting.

How railroads sparked modern street lighting

Ever since blowing Mr. Edison's first electric light bulb in 1879, Corning has pioneered in the field of lighting. It was then that modern lighting, including street lighting, had its beginning.

Curiously, it was the search for improved glasses, better lens design and uniform colors for railroad signals that led Corning into prismatic control of lighting.

Research pays off

Indistinct color signals confused engineers. Poor optical systems reduced distance of visibility. Sudden temperature changes shattered lenses. These shortcomings frequently caused serious accidents. Confronted with this problem, Corning established its policy of research in glass . . . basic ever since.

In 1908 the research paid off with the development of the first heat-resistant borosilicate glass. It withstood sudden temperature changes far better than ordinary lead and lime glasses then in common use. It provided the first dependable all-weather signaling glass for rail traffic.

Soon after, Corning helped establish uniform colors for signal lenses, colors which became the standard of all railroads in the U.S. and Canada. Corning continues today as a major supplier of lensware for railroads.

Through applied research and scientific control of manufacturing, Corning developed signal lenses for marine, aviation and street traffic. In the field of commercial lighting, Corning's lenses are used to control incandescent or fluorescent light for schools, stores, offices, hospitals and homes.

Street lighting benefits

The same degree of specialization founded upon research applies to Corning's street lighting refractors. They are optically designed to direct light on the roadway more effectively. And their efficiency in transmitting light does not diminish with age.

Many leading manufacturers of street lighting equipment use Corning's refractors for all of these reasons. It will pay *you* to insist on Corning.

Constant product and manufacturing research assure you of better designs and finished products, all with an eye to lower costs.

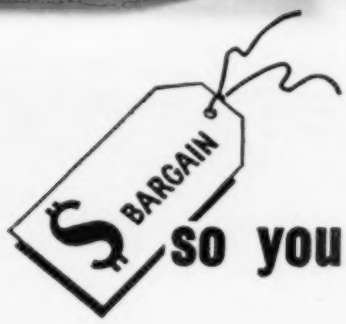
Precise optical design of lenses for control of light distribution and brightness is a science well known to Corning highway lighting engineers.

Automatic recording equipment is used to measure light distribution, brightness, transmission and diffusion characteristics for accurate product information.

Consulting engineering service is available through Corning sales and district engineers at all times to help solve application problems.

CORNING GLASS WORKS, CORNING, N. Y.

Corning means research in Glass



so you think you're saving money?

Far too often people figure lighting fixtures are all alike and buy by price tag alone. You may save a dollar or two on the price of each unit, but are you really saving money?

Today's carefully engineered lighting installations are planned with units that are designed to deliver more light at less cost. *Fewer units are required to secure the same results.* So, installation costs are less. And most important, power and maintenance costs are less during the whole life of the installation.

Take the Smithcraft DIRECTOR, for example. A recent comparison test by one of the nation's leading electric utilities clearly demonstrates that the Director produces more light and better light than ordinary fixtures.

Installed in literally thousands of banks, stores, schools and similar locations across the United States, the Smithcraft Director is in a class by itself for appearance, for quality of lighting and for soundness of investment. Be sure to get the complete story on the Smithcraft Director before relighting or when planning new installations. Ask us to send you our Smithcraft Director folder.

Photograph shows Director installation in the offices of the Credit Representative of the First National Bank of Boston, Empire State Building, New York.

BUY LIGHTING — NOT FIXTURES. INVEST IN AMERICA'S FINEST FLUORESCENT LIGHTING by
Smithcraft
LIGHTING DIVISION
CHELSEA 50, MASSACHUSETTS

(Continued from page 22A)

Student Members:
Boice, D. G., 302 Greene House E. Q., Ann Arbor, Mich.
Lawson, W. D., Wayne University, Detroit, Mich.
Rekasius, Z. V., Wayne University, Detroit, Mich.
Schemeck, C. J., University of Detroit, Detroit, Mich.

MID-SOUTH CHAPTER

Student Members:
Bazemore, J. C., Southern College of Optometry, Memphis, Tenn.
Kendall, C. R., Southern College of Optometry, Memphis, Tenn.
Thomas, J. T., Southern College of Optometry, Memphis, Tenn.

MILWAUKEE SECTION

Associate Members:
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Baker, W. R., Wisconsin Telephone Co., Milwaukee, Wis.
Griffith, G. J., Line Material Co., Milwaukee, Wis.

MISSISSIPPI CHAPTER

Associate Member:
Nicholson, H. W., Sylvania Electric Products Inc., Jackson, Miss.

MONTREAL SECTION

Member:
*Decarie, M. A., Ben Beland Inc., Montreal, Que.

NEW ENGLAND SECTION

Member:
Quinn, J. E., 248 Essex St., Salem, Mass.

Associate Members:
Kelly, W. R., General Electric Co., Boston, Mass.
Paresky, J. M., Eastern Fixture Co., Boston, Mass.

NEW ORLEANS SECTION

Associate Member:
Hagan, E. J., E. J. Hagan Co., New Orleans, La.

NEW YORK SECTION

Member:
Lipkins, S. P., Broadway Maintenance Corp., Long Island City, N. Y.

Associate Members:
Barchenko, A. E., Lightolier Inc., New York, N. Y.
Heidt, Christian, Duro Test Corp., N. Bergen, N. J.
Pascale, T. D., Jr., Johns Manville Corp., Manville, N. J.

NORTHERN CALIFORNIA SECTION

Members:
*Falge, F. M., General Electric Company, Oakland, Calif.
Walker, L. V., 120 Topeka Ave., San Francisco, Calif.
Wissing, C. H., Graybar Electric Co. Inc., San Francisco, Calif.

Associate Members:
Heywood, Stan, Prescolite Mfg. Corp., Berkeley, Calif.
Scholes, R. B., General Electric Supply Co., San Francisco, Calif.

OTTAWA CHAPTER

Associate Member:
Kennard, A. S., 175 Richmond Rd., Ottawa, Ont.

PHILADELPHIA SECTION

Associate Members:
Berg, P. F., Conrad F. Bond, Flourtown, Pa.
Riffkin, Albert, Stanley Electric Supply Co., Collingswood, N. J.

PITTSBURGH SECTION

Associate Member:
Ross, R. P., Westinghouse Electric Corp., Pittsburgh, Pa.

PUGET SOUND SECTION

Associate Member:
Penning, J. R., Smitheraft Lighting Division, Seattle, Wash.

QUEBEC CHAPTER

Associate Member:
Doran, F. M., Donnacona Paper Co. Ltd., Donnacona, Que.

ROCKY MOUNTAIN SECTION

Associate Members:
Humphrey, J. M., Appleton Electric Co., Denver, Colo.
Norton, R. J., Line Material Co., Denver, Colo.
Rink, F. J., Swanson-Rink & Associates, Denver, Colo.

SOUTHEAST FLORIDA CHAPTER

Associate Member:
Tornow, C. B., Jr., McDonald Electric Co., Inc., Miami, Fla.

Student Member:
Wendt, R. B., University of Miami, Coral Gables, Fla.

SOUTHERN CALIFORNIA SECTION

Associate Members:
Coultas, R. E., Southern California Edison Co., Oxnard, Calif.
Seid, Ben, Dept. of Water & Power, Los Angeles, Calif.
Weston, R. B., City Hall, Culver City, Calif.

SOUTHERN COLORADO SECTION

Associate Member:
Even, R. F., Southern Colorado Power Co., Pueblo, Colo.

SOUTHWESTERN SECTION

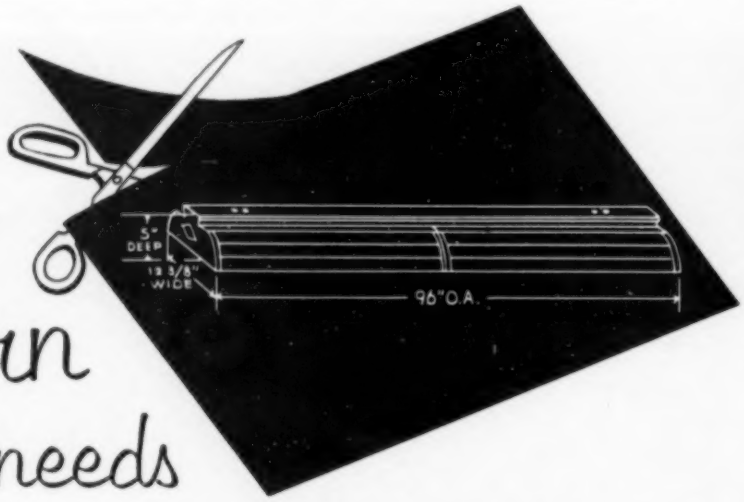
Associate Member:
Shearer, C. F., Graybar Electric Co., Dallas, Texas.

TENNESSEE VALLEY SECTION

Associate Members:
Brantley, R. B., Graybar Electric Co., Inc., Nashville, Tenn.

(Continued on page 30A)

We can Cut the Pattern to suit your needs



L & P LIGHT & POWER UTILITIES CORP.

1035 Firestone Blvd. Memphis, Tenn.

L & P FIXTURES are made in our own plant from start to finish

From the very first shears that cut the metal to size, L & P fluorescent and slimline fixtures are made right in our own plant, every step of the way. That's why we can assure you of the right light for each specific job.

We're equipped to assist you in planning and research—and then to go ahead and manufacture the complete fixtures to your particular requirements.

For the quality of "custom-made" at the cost of standard fixtures, write or wire for our catalog and prices today. Distributed by Electrical Wholesalers Only.

YOU EXPECT THE BEST VALUE FROM G-E FLUORESCENT LAMPS

New G-E "Rapid Start" lamps light up twice as fast as others

This series of pictures shows how General Electric can save you the annoyance of waiting for light.

All the lamps were started as the second hand on the clock reached zero. Within two seconds, the G-E Rapid Start lamps—right of the clock—were fully lighted. It was nearly *six* seconds before all the regular lamps, left, lit up.

G-E Rapid Start lamps eliminate the starter, cause of up to half of regular lighting maintenance troubles. They have long life, too. Reason: a triple-coil cathode that holds more starting chemical.

General Electric Rapid Starts are another example of why you can *expect* the best value from G-E fluorescent lamps. For free folder, "Facts About Rapid Start", write: General Electric, Dept. 166-IE-3, Nela Park, Cleveland O.

You can put your confidence in—

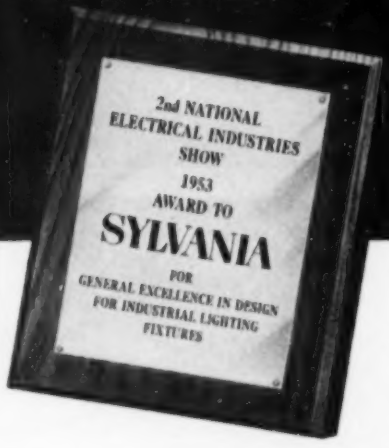
GENERAL ELECTRIC

BEST DESIGNED INDUSTRIAL FIXTURE

New Sylvania IC Fixture...

wins award for best design at Electrical Industries Show

SAVES MAINTENANCE DOLLARS, TOO!



In addition to top design honors, this improved Sylvania IC Fluorescent Fixture also wins in lighting efficiency and low maintenance.

Metal parts are Bonderite treated to resist deterioration. Channels, shielding, and steel panels finished in Sylvania's Miracoat baked enamel offer 86% reflectivity . . . keep their high efficiency for years.

Wonderfully versatile!

This fixture meets the needs of scores of industrial applications calling for high levels of illumination. Available in 4, 5, and 8-foot lengths, with V-type crosswise shielding or 45 x 45° louvers. Also may be equipped with the new T-17 low-brightness lamps for critical seeing tasks such as the machining of specular metals.

For full details about this important fluorescent unit, see your Sylvania Representative or write to Dept. 4X-3503, Sylvania.

SYLVANIA

Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

In Canada: Sylvania Electric (Canada) Ltd., University Tower Bldg. St. Catherine Street, Montreal, P. Q.

LIGHTING • RADIO • ELECTRONICS • TELEVISION

(Continued from page 28A)

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Patterson, H. M., The T. Eaton Co., Ltd., Toronto, Ont.
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Background should include experience in lighting recommendations and handling with architects and engineers. Advise other lines and areas covered. We manufacture a complete line of incandescent, fluorescent, Plexiglas, church lanterns and exit lighting. Gruber Lighting, 125 S. First St., Brooklyn 11, N. Y.

WANTED—ILLUMINATING ENGINEER

Good opportunity with well established business for ambitious man with B.S. in E.E., specialized in lighting and with sales ability. To call on Consulting Electrical Engineers, Architects and Utility men. Give experience, references, family status and income expected. Replies confidential. Address Box 201, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

TOP INDUSTRIAL SALES ENGINEER

Available at once, 40 years of age, 15 years sales experience. Heavy background in floodlighting football and baseball fields, sawmill and industrial plants, also interior as well as exterior layouts. Member of I.E.S. Well known on Pacific Coast. Top sales record. Address Box, 204, Publications Office Illuminating Engineering Society, 1860 Broadway, New York 23. N .Y.

SALES MANAGER

A well established company manufacturing lighting equipment needs a manager, thoroughly acquainted in architectural, engineering and electrical trade circles. This man must be able to take complete charge of advertising, sales promotion and sales personnel. Starting salary will be commensurate with ability and background. Future earnings will be based on accomplishments. Write giving resume of past activities and earnings together with any other data that will enable us to judge ability. Address Box 205, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

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UNMOUNTED CELLS

6 cell sizes.
15 to 750 micro-amperes at 100 ft.-candles illumination.

WRITE FOR BULLETIN PC-649

HERMETICALLY SEALED

DP-2 (shown above) 25 microamperes*
DP-3 — 50 microamperes*
DP-5 — 600 microamperes*
*At 100 ft.-candles illumination

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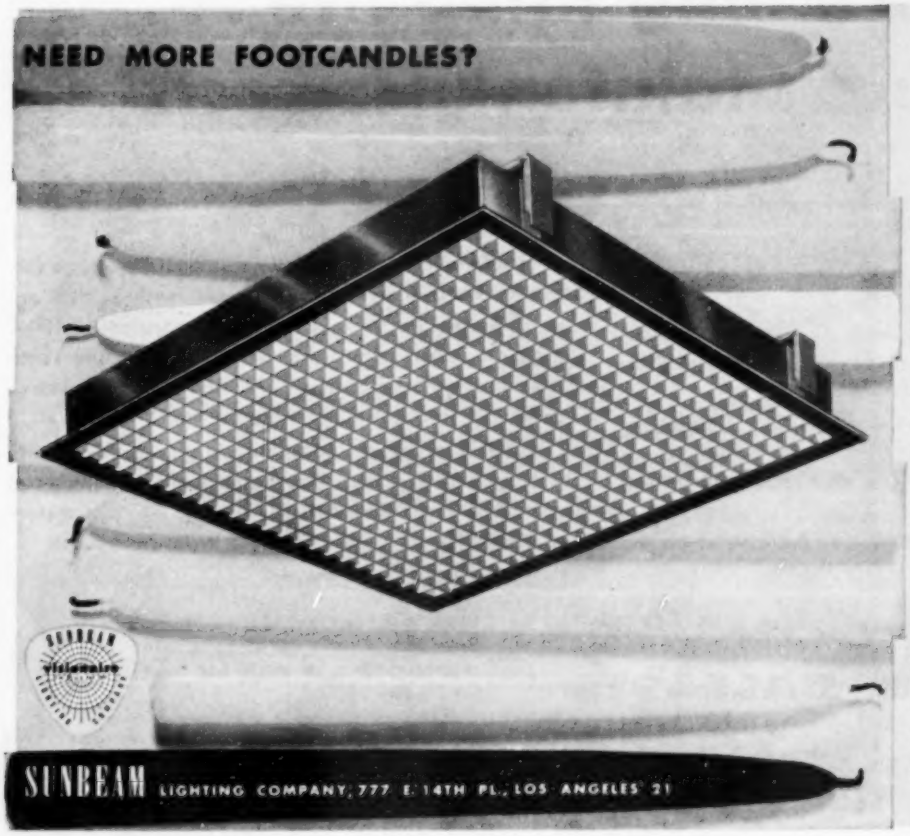

You CAN have more footcandles of scientific illumination by specifying Sunbeam's new "large area" recessed light modules, the #3800 series. Acting as large "area sources," these 4-foot (nominal) squares produce higher intensities with lower brightness. This means more comfortable lighting in stores, banks, display rooms and interiors having high ceilings. Finished in white enamel, these sturdy units are available with metal louver or plastic diffusing panels which open as single elements. The fixtures take four to ten 48" fluorescent and slimline lamps.

Sola Constant Wattage Ballasts for Rapid Start Lamps

assure long lamp life . . . reduce maintenance costs

The price of the lamp is only a small part of the total cost of relamping a fluorescent ceiling fixture. There is also the loss of efficiency resulting from lack of light until the lamp is replaced, plus salary for one or more maintenance men to relamp. High maintenance costs are, however, no longer a problem with Sola-ballasted, rapid-start fluorescent lighting systems. This is true for two reasons.

First, Sola Rapid-Start Ballasts have a higher open-circuit voltage (300v.) from the lamp to the starting aid for positive starting and consequent long starting life.

Second, Sola Rapid-Start Ballasts have an unusually low peak/rms current ratio (approx. 1.5 at 118v.)—an important factor in long lamp operating life.

In addition, the patented Sola Constant Wattage Circuit results in lumen output constant within ±2% regardless of line voltage fluctuations from 106-130v. Regulated operation assures fixture manufacturers that their units will deliver specified lumen output . . . assures users that they get all the light for which they pay.

Leading architects, consulting engineers, and users want good, dependable, economical lighting. They can get it with a rapid-start fluorescent lighting system operating from a Sola Constant Wattage Ballast.

SOLA *Constant Wattage* **BALLASTS**

We will be happy to give you all the facts. Phone for a Sola sales representative, or write for Bulletin 3C-FL-191.

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Mercury Vapor Lighting • Luminous Tube Signs
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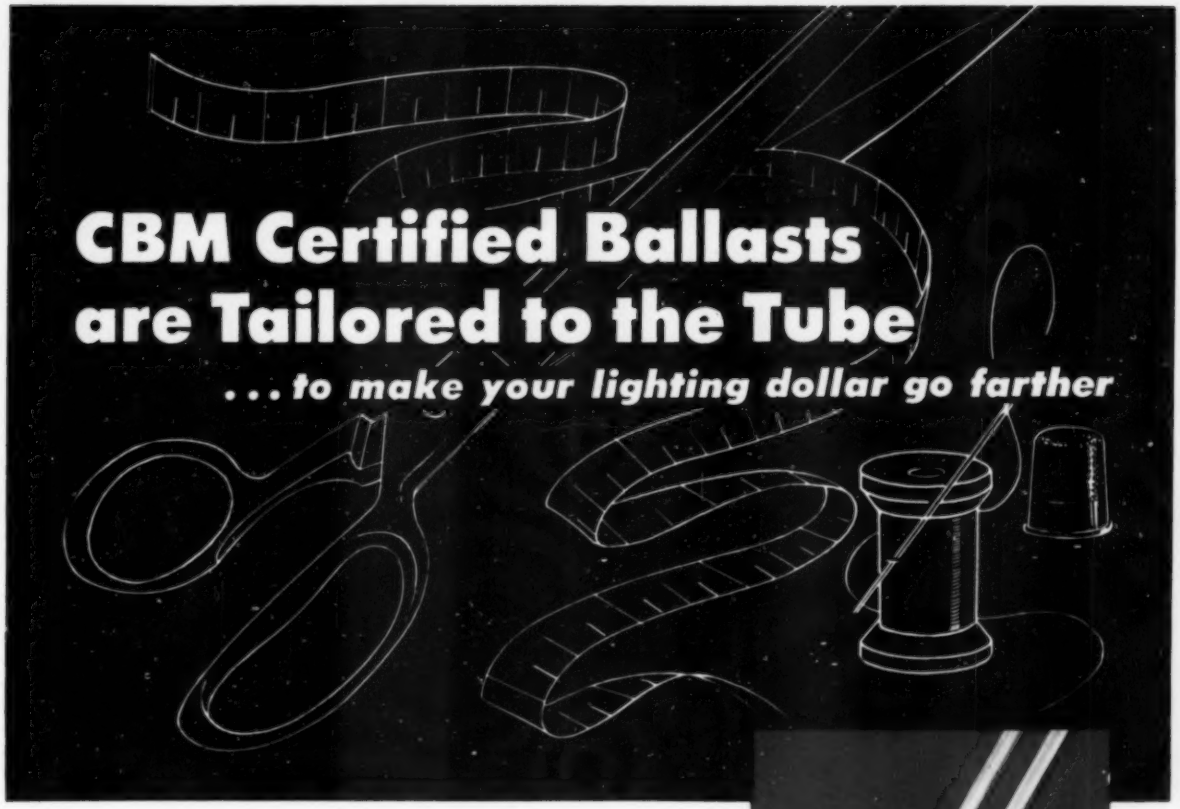
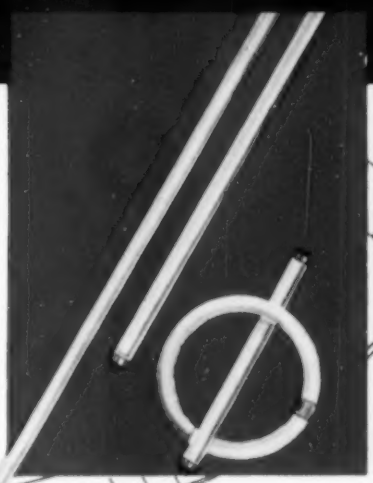
CBM Certified Ballasts are Tailored to the Tube

. . . to make your lighting dollar go farther





The heart of a fluorescent fixture is the Ballast.

Best lighting performance is assured by accurately matching ballasts to fluorescent tube requirements.

CERTIFIED BALLASTS are so matched. Built to exacting specifications designated by the Certified Ballast Manufacturers,* tested, checked and Certified by ETL, CERTIFIED BALLASTS truly are "Tailored to the Tube!"

That's why CERTIFIED BALLASTS assure:

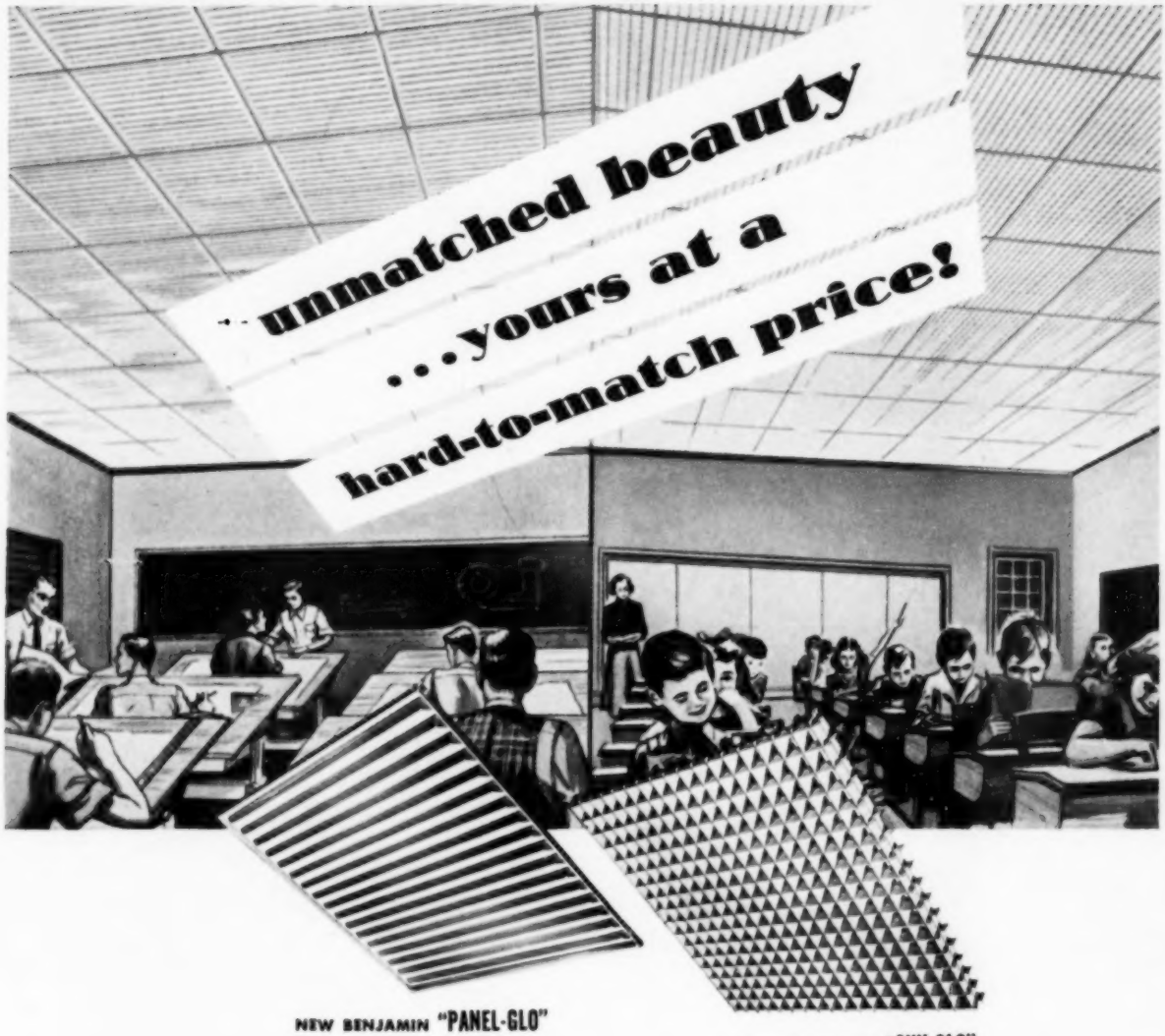
LONG LAMP LIFE — FULL LIGHT OUTPUT
LONG BALLAST LIFE — FREEDOM FROM OVERHEATING
QUIET, TROUBLE-FREE OPERATION

And that's why, today, the large majority of fluorescent fixtures for general lighting service are equipped with CBM Certified Ballasts.

CERTIFIED BALLAST MANUFACTURERS

**Nine leading manufacturers make CBM CERTIFIED BALLASTS.*

2116 KEITH BLDG., CLEVELAND 15, OHIO



NEW BENJAMIN "PANEL-GLO"

NEW BENJAMIN "SKY-GLO"

You need not forego the many advantages of a Benjamin Luminous Louvered Ceiling... comparative costs show why!

Even when you compare on the simple basis of material and fixture costs alone, it is often more economical to use a Benjamin Ceiling as against conventional individually-hung units. Especially in areas where it is desired to modernize by lowering the ceiling to cover up ugly ducts, pipes or cracks, Benjamin Louvered Ceilings are even more economical. In addition to furnishing higher light-levels, these "ceilings of light" actually modernize old-fashioned rooms to make them "look young again" without plastering or other re-decorating expense.

Send for FREE "Sky-Glo" and "Panel-Glo" Data Bulletin. Benjamin Electric Mfg. Co., Dept. I, Des Plaines, Illinois.

NEW Simplicity brings down installed price!

● New, practical, easy-to-handle 3' x 3' translucent panels or louver sections.

NEW, Easier installation brings down installed price!

No need to order "fill-in" size panels. Trim them yourself with scissors... right on the job... to the exact shape desired!

New metal FINISHING STRIPS neatly hide trimmed edges on either louver or luminous-panel jobs.

NEW, proven TRANSLUCENT plastic material means MORE LIGHT with CONTROLLED BRIGHTNESS. (Same material used for "Sky-Glo" and "Panel-Glo.")

Benjamin "Sky-Glo" and "Panel-Glo" Ceilings are approved by Underwriters' Laboratories

NOW, figure the complete price of a ceiling-lighting job by the sq. ft.!

Sq. ft. price includes all panels or louver sections as well as all the channels, fittings, etc. you need to complete the installation!*

No calculating, no figuring... just know the area of the room!

No layouts necessary for regularly-shaped rooms.

*lighting equipment not included.

BENJAMIN *Lighting Equipment*

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